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Evening Meeting.

Monday, March 2nd, 1874.

ADMIRAL SIR HENRY J. CODRINGTON, K.C.B., in the Chair.

NAMES OF MEMBERS who joined the Institution between the 16th of February and the 2nd of March, 1874.

LIFE.

Dawson, W. A., Lieut. 6th Inniskillen Dragoons.

ANNUAL.

Barnett, E. R. de B., Lieut. 4th King's Own Regiment.
Probyn, D. M., V.C., C.B., Maj.-Genl., Unatt.
Craster, G. A., Major R.E.
Ackers, C. S., Lt.-Col. R.E.
Dawson, D. F. R., Sub-Lieut. Coldstm. Gds.
Lodger, Frank, Captain R.A.
Nolan, J. Philip, Captain R.A.
Marshall, John W., Captain, M.P, Rifle V., N.Z.
Woodward, W. W., Major R.H.A.
Glasspoole, W. A., Lieut.-Colonel Bo. S. Corps.
Gill, F., Captain 39th Middlesex R.V.
Smyth, E. S., Major-Genl., Unatt.

FURTHER EXPERIMENTS WITH THE BOW- AND STERN-SCREW-PROPELLER.

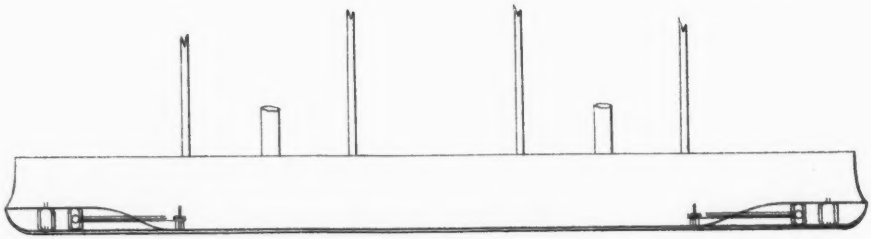
By R. GRIFFITHS, Esq.

SINCE I had the honour of reading a paper on my Patent "Bow- and Stern-Screw Steamship" here, in June last,* I have made some important and interesting discoveries in the course of my experiments at the Royal Horticultural Gardens, Kensington, which will explain several important facts in connection with screw-propulsion hitherto not fully understood. I trust that you will consider this sufficient cause for my again trespassing on your time.

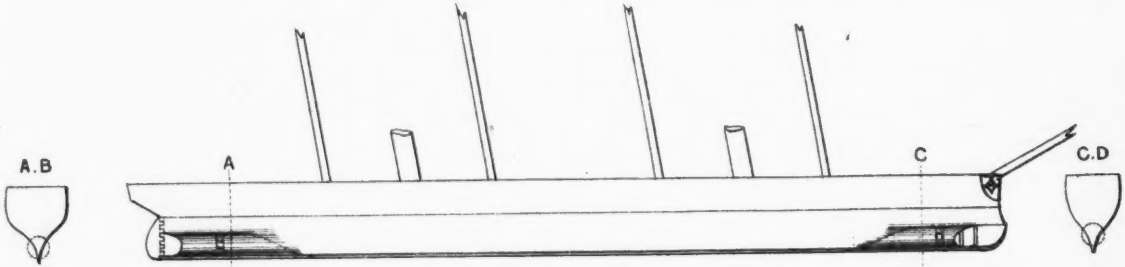
It is generally admitted that barely 50 per cent. of the power exerted by the engines, is made available to propel a ship, either by screw or paddle-wheels, or by any other plan of propulsion which has as yet been practically used, the other 50 per cent. being lost in some way, to account for which there are a variety of opinions: my present object is to explain how this great loss of power takes place in screw propulsion, and the way to remedy it.

* See Journal, vol. xvii, page 734 *et seq.*—ED.

Since the introduction of the screw for propelling ships, the general impression has been that any further improvements to be effected, would be in the screw itself, and I suppose there have been some hundreds of so-called improvements brought out which were expected to work wonders; but what have been the results? So far as the screw itself is concerned, there has been no other real improvement than that which I introduced 23 years ago, by the filling up of the centre portion to the extent of one-third of the diameter, and making the blades narrow at their extremities in contradistinction to the then existing plan, by means of which I obtained a screw which offered less resistance when the vessel was under sail alone, eliminated more power, gave greater speed, and also reduced vibration. I afterwards made a slight improvement in 1858 by bending the ends of the blades towards the ship, on account of which the screw offered greater resistance to the engines by means of the water that was drawn by it towards its periphery coming in contact with the propelling sides of the blades instead of with the leading sides, as is the case with straight blades; the advantage of this alteration was very apparent when the ship was under canvas as well as under steam, as was proved to be the case in some trials between Her Majesty's ships "Warrior" and "Revenge." I contended, and do still contend, that a large boss of one-third diameter of the screw and two narrow flat blades or oars set at an angle that will keep the engines at such a speed as the boilers can supply them with steam, will give nearly as good a result in propelling the ship as the best screw that has yet been introduced. I have for several years given up the idea that any further improvements were to be realised by any further change in the configuration of the screw, and consequently turned my attention to the mode of applying it. My first patent in this direction, obtained in 1871, was for applying a screw at the bow of the ship within a tunnel in combination with the screw at the stern in the ordinary way; I afterwards found very great advantages in having both the bow and stern screws in tunnels, for which I obtained a patent in 1872. I was much suprised to find, when I doubled the power by applying one portion to the bow-screw and the other to the stern-screw, each within a tunnel, that the speed of the model increased nearly as the square-root of the power, but if I doubled the power on either the bow or stern-screws separately, the speed of the model in that case increased only as the cube-root of the power. It is well known that the resistance to bodies propelled through the water varies as the square of the speed, while the power required is as the cube. At last it occurred to me that this great advantage must be due to the increased quantity of water that was passed through the screws within the tunnels, when both were at work, over what was done in the same time when only one screw propelled the model, for since one screw propelled the model from 58 to 60 ft. in 60 seconds with 600 revolutions of the screw, and with the two screws of the same pitch together, from 96 to 100 ft. in the same time and with the same number of revolutions, there must, therefore, be at least 50 per cent. more water pass through the tunnels in the same time, and the thrust given to the screw-shafts



BOW AND STERN SCREW RAM OF THE FUTURE.



OCEAN STEAMSHIP OF THE FUTURE.

B

OCEAN STEAMSHIP OF THE FUTURE.

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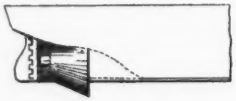
STERN OF SINGLE SCREW SHIP.

STERN

STERN.

BOW.

SHIP WITH BOW SCREW ONLY.



WITH ENLARGED ENTRANCE TO TUNNEL TO SUPPLY FROM 40 TO 50 PER CENT MORE WATER TO SCREW.

WITH FULL LINES SHEWING SUITABLE ENTRANCE TO TUNNEL.

WITH FINE LINES SHEWING SUITABLE ENTRANCE TO TUNNEL.

WITH BELLMOUTHED ENTRANCE TO TUNNEL.

TUNNEL BELLMOUTHED TO ADMIT FROM 40 TO 50 PER CENT. EXTRA OF WATER TO THE SCREW.

J. Jobbins

Pl. VII.

must be in proportion to the quantity of water acted upon by the screws.

Since I read my paper here last June, I have been enabled to discover and prove what I could not then explain and account for, and in order to demonstrate what I supposed to be the cause of the great increase in speed when both bow- and stern-screws were at work over what was obtained when the same amount of power was used on one screw in the ordinary way, I had the mouth of the stern-tunnel enlarged to the extent of 50 per cent., and this enlargement came below the keel. This it might be supposed would be an obstruction and cause a considerable loss of speed, but I was agreeably surprised to find when I tried it, that I had a gain of nearly 20 per cent. in speed; this at once unravelled the mystery which had puzzled me for some time.

I find that Colonel Beaufoy, in his experiments on the resistance of plain surfaces propelled through water, states that one foot square offers about 350 lbs. at a speed of 12 knots per hour, and in the account given of the experiments made in 1845 on Her Majesty's ship "Rattler," I find that the screw of that ship was 10 feet diameter and 11 feet pitch, making 104 revolutions per minute, which would give a speed of about $11\frac{1}{2}$ knots to the water through the screw, provided she had a sufficient supply of water. The area of the screw's disc being 78 square feet multiplied by 350 lbs., gives a pressure of about 12 tons to the screw-shaft, but the actual thrust shown by the dynamometer appears only to have been 4 tons 3 cwt., therefore the quantity of water that was forced through the screw, could not have been more than one-half the requisite quantity, according to its pitch. I have found, by my experiments, that as the supply of water to the screw is diminished, so the power required to revolve it increases, and the speed of the ship diminishes. This was proved in 1844 by experiments made on Her Majesty's ship "Dwarf," a vessel with a fine run, which made a speed of 9·1 knots, with 32 revolutions of the engine per minute; the stern was afterwards made full by layers of planking, care being taken that the filling up was in conformity with the lines of the vessel, and when tried, the speed was reduced to 3·25 knots, and the engine to 24 revolutions. One layer of the planking was then removed, and the speed rose to 5·75 knots, and the engine to 26·5 revolutions; when all the planking was removed, the ship made her original speed. This is accounted for in the following manner: for example, take the screw of the "Rattler," 11 feet pitch, making 104 revolutions per minute, a blade would pass the same point about $3\frac{1}{2}$ times per second, driving back a slice of water 5 feet 6 inches wide, the time before the following blade comes up is so short that the water cannot flow into the space so as to fill it; especially at the top of the screw, whilst the bottom part and some distance up its sides will be better supplied on account of the density of the water being there greater, and also on account of the current rising upwards and on each side of the stern, feeding the screw. I believe that a portion of the water which flows to fill the space at the bottom of the screw, is carried round by the blades to the top, where there is a deficiency. The dynamometer diagrams of the thrust on the screw-shaft of "Rattler" show the thrust to be about 5 tons when the blades were

vertical, and $2\frac{1}{2}$ tons when horizontal; this is attributed to the bottom blade meeting the dead water which followed the ship, but the real cause is, that the bottom blade came into denser water, which rose upwards to fill up the space the ship had left; and thus gave the screw a better supply, and consequently recorded a greater thrust to the screw-shaft.

There are three important points to be considered in screw-ships, viz., the propeller, the ship, and the engine. In the first, there have been no improvements with regard to speed since 1840; secondly, with respect to the ships, the best types of ships were described by the old builders as having cod's heads and mackerel's tails, and the length equal to *three to four times* their beam. No better sea ships have been built than our sailing frigates of former days, but since the introduction of the screw, the shipbuilder has been obliged to arrange his plans to suit the propeller, for experience has shown, that the deeper the immersion, the more effective the propeller, and consequently steam ships are now being made with an enormous draft of water, in proportion to the beam. The eel therefore might now be taken for the type of modern screw ships, which are made in length 10 to 14 times the beam; and, had it not been for the introduction of iron for ship building, the screw would never have succeeded to the extent it has done. This necessarily great increase of length gives the shipbuilder no chance of improving the form of his ships, from a naval architectural point of view; this is not, however, the case in my system, as whatever form or type of ship will be best for sailing, will also be the best for the adoption of bow- and stern-screws.

The great improvement in steam ships during the last 30 years is to be found in their engines, from which about three times more indicated power is obtained now, with the same consumption of fuel, than formerly, as well as other important improvements that have been made in this department.

My attention was first drawn to the necessity of having bow- and stern-screws, on account of the danger attending the employment of ships of such enormous length in proportion to their beam; for every sailor must be well aware that, should an accident occur to their machinery in a heavy sea, or on a lee shore, there would be but a poor chance of saving them, especially if, with machinery disabled, they should get into the trough of the sea. I expected that the shipowners would have readily availed themselves of my arrangement, on account of the safety it offered the ship and its passengers, and also that the Admiralty would have seen and promptly recognised the advantage and safety it would have been to ships of war; now also that the high price of coal is being felt by the shipowners, they may be induced to consider whether it will not be to their interest, as well as for the protection of their passengers, to adopt my system.

In this paper I have confined myself to the advantages gained in speed or the saving of fuel by my system; but I will briefly name eight other important advantages in connection with it.

1st. Thorough protection to the propellers.

2nd. Smaller screws and engines only are required.

3rd. No vibration whatever is produced by the propellers.
4th. Ships so fitted can be stopped much sooner in case of danger.
5th. There will be no loss of speed through racing of the engines.
6th. Greater facility for steering and manœuvre.
7th. Greater safety through dividing the power.
8th. Ship can carry more canvas, and sail better.

To sum up the result of my experiments, I find that to obtain the advantages of my system, the propellers must be placed in tunnels, by means of which an extra supply of solid water will be kept up to them, which cannot be effected in open water; this extra supply of water can be obtained by using the bow- and stern-screw together, or in single screw ships, either at the bow or stern tunnels, by having the tunnel-mouths enlarged or bell-mouthed.

It may be thought that there would be a loss of speed through the friction of the water passing through the tunnels when the ship is under canvas only; this, however, is not the case. I have had the models drawn by a string wound over a drum, worked by the same power or spring as used to propel them with the screws, with the following results:—1,200 revolutions of the spring power propelled the model of an ordinary ship 120 feet in 120 seconds by the screw propeller, whereas 1,200 revolutions of the same spring by a string wound over a drum gave 120 feet in 60 seconds; the same result was obtained by the model with the tunnels. Now the model with the tunnels and screws in them gave 1,200 revolutions in 62 seconds, or 2 seconds more.

The following is a *résumé* of the results of my recent experiments:—

Model fitted with the screw at the stern in the ordinary way—
1 Power 600 revolutions gave 58 feet to 62 feet in 60 seconds
2 „ „ „ 75 „ 80 „ „

Model with the tunnels, with one screw in either bow- or stern-tunnel—
1 Power 600 revolutions gave 60 feet to 64 feet in 60 seconds
2 „ „ „ 76 „ 82 „ „

With both the screws in tunnels—
2 Power 600 revolutions gave 95 feet to 100 feet in 60 seconds

Model drawn by string over a pulley—
1 Power 1,200 revolutions gave 120 feet in 60 seconds
2 „ „ „ 150 „ „

In conclusion I beg to state that I am much indebted to Colonel Devenport for the permission given me to carry out my experiments at the Royal Horticultural Gardens, Kensington, and to his assistants and the officers of the establishment, for the facilities they have so freely afforded me.

APPENDIX.

List of some of the trials made at the Royal Horticultural Gardens with models 5 feet long, $7\frac{1}{2}$ beam-screws, $2\frac{3}{4}$ diameter. Time in each run 60 seconds mean of several runs being given.

Pitch of Screw.		Revolutions of screw.	Distance.
in.	HALF POWER.		ft. in.
3½	Model of a ship with the screw at the stern ordinary way	632	59 0
,,	,, ,, bow-screw in open water	618	45 6
,,	,, ,, the bow-screw in bottom discharge tunnel	638	62 6
,,	,, ,, 50 per cent. extra supply of water to the screw	643	68 6½
,,	,, ,, screw in the stern in bottom discharge tunnel	607	61 0
,,	,, ,, 50 per cent. extra supply of water to the screw	626	71 7½
,,	,, ,, screw outside the bow in a casing	658	58 7½
,,	,, ,, screw at the stern in a casing	612	48 0
,,	,, ,, screw at the stern in open water with half casing below it three times the length of the screw	562	36 0
,,	,, ,, the half casing above the screw	630	58 2
	FULL POWER (*Half power of each Screw*).		
,,	Model of an ordinary ship with twin screws	614	81 9
,,	Model of a ship with screw at bow and stern in open water	680	87 2
,,	,, ,, the bow-screw and side-discharge tunnel (as fitted to the "Alpha," at Lynn) and the stern-screw in open water	680	84 0
,,	,, ,, screw in the bow bottom discharge-tunnel and the stern-screw in open water ordinary way	650	96 0
,,	,, ,, screws in bow- and stern-bottom discharge-tunnels	670	101 6
	FULL POWER (*With single Screw*).		
5	Model of a ship with the screw at the stern in the ordinary manner	674	78 6
,,	,, ,, the screw in bottom-discharge bow-tunnel	674	80 8
,,	,, ,, the screw in bottom-discharge stern-tunnel	677	82 4
	Experiments made to ascertain the most effective position for the screw both at bow and stern of the ship:—		
3½	Model perfect ship screw at bow in open water close up to the stem-post	621	47 3
,,	Same with the screw moved ¾ in. forward of stem post	642	47 9
,,	,, ,, ,, 1¼ ,, ,,	643	47 9
,,	,, ,, ,, 2¼ ,, ,,	643	47 9
,,	,, ,, ,, 3 ,, ,,	645	47 9

Pitch of screw.		Revolutions of screw.	Distance. ft.	in.
3½ in.	Screw at stern in the open water close to the stern-post in the ordinary manner	585	54	6½
„	Same ⅜ in. from stern post	592	61	8
„	„ 1¼ „ „	603	62	7
„	„ 2¼ „ „	608	63	6
„	„ 3 „ „	615	64	5
„	„ 3¾ „ „	615	64	5
	Experiments made to ascertain the effect of the screw with various supplies of water. Pitch of the screw 3½ in. in all the following experiments :—			
	Model of a ship with screw at stern in the ordinary way	636	58	0
	Same with a disc placed before the screw 1⅜ diameter, area 1·5 square in.	582	48	0
	Same with a disc placed before the screw 1⅛ diameter, area 3 square in.	565	28	0
	Same with a disc placed before the screw 2⅜ diameter, area 4·5 square in.	550	0	0
	Same with a disc placed before the screw 2¾ diameter, area 6 square in.	485	0	0
	Screw in the stern tunnel with disc before the screw :— The 1st disc 2¾ in. diameter, same size as tunnel, allowing of no water	372	0	0
	The 2nd disc 2½ in. diameter, allowing 1 in. area for the water	412	6	0
	The 3rd disc 2¼ in. diameter, allowing 2 in. area for the water	465	7	0
	The 4th disc 2 in. diameter, allowing 3 in. area for the water	490	9	0
	The 5th disc 1¾ in. diameter, allowing 4 in. area for the water	565	26	0
	The 6th disc 1½ in. diameter, allowing 5 in. area for the water	585	52	0
	The 7th disc 0 in. diameter, allowing 6 in. area for the water	600	62	0
	The 8th with tunnel-mouth enlarged, giving 7½ in. water area	613	69	0
	The 9th with tunnel-mouth enlarged, giving 8½ in. water area	630	71	0
	The 10th with tunnel-mouth enlarged, giving 9¼ in. water area	618	69	0

ROBT. GRIFFITHS.

40, Kildare Terrace, Bayswater,
London, *January* 12, 1874.

P.S.—The models are propelled by two separate springs, which can be used on each separate screw, or together on one screw, the power being equal on each spring, and they will propel the screw 2,000 revolutions when it is wound up, the pitch of the screw being fixed so as to make about 600 revolutions in 60 seconds; so that the power exerted by the springs beyond 600 revolutions will only equal say two-thirds the power at each revolution of what it was when the spring commences to give out its power.—R. G.

The CHAIRMAN: Will you explain the models, as there may be some gentlemen present who have not seen them.

Mr. GRIFFITHS: This is a model of a vessel with the bow-, and this with the stern-screw, in either of them the single power will propel the model 60 feet in 60 seconds. But when I added the bell-mouth to the tunnel leading to the screw, I found that it gave the screw just 50 per cent. more water, that is, as the model moves along, there is a better rush of water to it. If it worked at the rate of 200 h.p., when I added this bell-mouth it gave a speed due to 350 h.p., so that in ordinary circumstances there is 150 h.p. lost for want of water to the screw. If I work both bow- and stern-screw together, it does not require the bell-mouth; it does neither good nor harm, because as the model goes 100 instead of 60 feet, 40 feet more water passes through the tunnels, which is about the supply the propellers require. I cannot find that anybody ever yet complained of deficiency of water to the screw, though they always wanted to have greater depth for it to work in. The greater the depth, of course the greater the density of water over it; but people never supposed that the screw had not plenty of water to feed it. But there was the deficiency—it was shortness of water supplied to the screw. I believe that if your screws are near the surface, provided you get a sufficient supply of water to them, they are just as effective as if they were fifty feet below. You must supply as much solid and undisturbed water as the screw can lay hold of in work, in order to get proper effects from it. This will explain directly what takes place with the ordinary screw. The general opinion was, that the centrifugal action of the screw threw the water outwards. There never was a greater error: the screw draws the water in instead of driving it out (experiment). You observe during this experiment that the motion of the screw does not drive the flame of the candle *outwards*, but on the contrary, sucks it in. As far as I have been able to make out, it is the lower blade of the screw that propels the ship, and none of the pushing work is done by the upper blade. The water, as the ship moves along, rises up to fill the space left by the stern, and consequently she gets a greater quantity of water to supply the bottom blade, and that water no doubt is carried upwards with the blade to the top side and driven out there. Therefore all the power taken to bring the water to the top from the bottom is wasted, and also the power employed to draw the water in. That is where the great loss of power in the screw is.

Captain BURGESS: Did not you mention that when the blade is at the top, it has no effect at all?

Mr. GRIFFITHS: It is only when the blade was below that there was a thrust on the screw-shaft of five tons, but when the blades were horizontal, it was only $2\frac{1}{2}$ tons. Therefore there was very little thrust when screw was in a horizontal position, as the dynamometer showed.

Mr. WILLIAM SMITH, C.E.: I suggest that an indicator diagram showing the resistance, would be represented by a double curve. The lower portion representing the minimum of power, would be that represented by the blades when they were horizontal. The greatest amount of force or resistance would be when the blades were vertical, and this would be mainly due to the performance of the lower blade (Mr. GRIFFITHS: Yes, it being in the solid water).

The CHAIRMAN: Perhaps the meeting would like to know how you strengthen the bow or stern for ramming?

Mr. GRIFFITHS: I throw my screw a little back, and you have all the straight beam in front of it, *i.e.*, solid iron beyond the rudder post (see Plate). I put my helm here (pointing to the diagram); that is all solid iron for several feet. The bow is stronger than you can make these fine bows and altogether stiffer. It is built or forged all in one piece.

Captain BEAMISH, R.N.: Do you require more steam power, having the two screws—(Mr. GRIFFITHS: No; less, by one half.)—and I see that you propose that the aperture shall be different when you have fine lines to what it is when you have full lines?

Mr. GRIFFITHS: They are exactly the same when there is a screw at both ends, but if I have a ship with only a screw at the stern, I should put a bell-mouth for that screw to have more water, or a better supply of more solid water, as it were; or, if it is at the bow, I should put the bell-mouth at the bow. When both

screws are working together, they get plenty of water without the bell-mouth, as the vessel is propelled through the water more rapidly, and more water is fed to the screws.

Mr. SMITH: On looking at the diagrams (see Plate), it is quite clear that each of the tunnels is a curved tube, the forward or bow screw has a bell-mouth in front of it, giving 30 to 50 per cent. more area than the aperture in which the screw is working, and in the stern tunnel it is quite clear the proportionate increase of area is about the same, or perhaps rather more, at the lower part of the screw where the water is admitted. The notion is, as it seems to me, to offer the largest area to the admission of the water through a bell or funnel mouth, and then to condense it, if I may use that term, or drive it in a more solid mass against the front and acting side of the screw: is that so?

Mr. GRIFFITHS: That is so, so that the water comes solid against the screw. As one blade drives the water back, the water follows that blade so that the next gets the solid water, instead of being only half full. If you take a screw of any pitch, you will find that if it had a full supply of water, there would be a thrust double what there is when it is applied and worked in the ordinary way. The reason is that the screw cannot get enough water as a resistance to drive back and force the ship on; if it could get enough water, the whole power of the engine would go to propel the ship, less friction only; and, if you were to rotate that screw in the water, the ship being moored fast, and not being propelled through the water, the screw's revolutions being continued in the same body of water, it would take nearly double the power to get the same number of revolutions. The less the supply of water to the screw, the greater is the power that it takes to revolve it.

Mr. SMITH: Surely that must be in relation to the power and the motion of the ship as a body moving in water. If your ship was suspended *out of water*, which is the extreme case, it certainly could not be so. It is merely in relation to the water in which the ship is moving, and of the screw obtaining a full and free supply. I think there is one point that attention should be called to, viz., that whereas in that model the filling-out of the after-body, and the bow lines, would appear to be part of the construction of the ship, it is not so shown in those diagrams (see Plate). Evidently that is intended for a section of the bow, taken on the line C.D., and this one on the line A.B. There the quantity taken out of the capacity of the ship must be really very small indeed; for, looking at the lines where that section is taken, the apparent adding to the breadth of the vessel at that point is really only a tube or hollow structure superadded to the sides, a very slight increase of dead weight and nothing more. In the case of the bow, it is more evident there, as there is but a covering, as it were, to form a shield to the screw, and nothing material is taken out of the capacity or body of the ship. Now when the question was answered by Mr. Griffiths with respect to the construction of that model, what he answered did appear to me to leave a wrong impression. Take, for instance, the suggestion that Mr. Griffiths recently made about altering the "Great Eastern" steamship. All that would be required in that case would be to take two portions of a tube, cut away the central portion represented by the section of the ship itself, and with pieces of angle iron attach those two halves (or at any rate the two portions) of the tube, one to each side of the ship. Then remove so much dead wood, or what would be in the ship called the dead wood, remove that and so make a tunnel, the mouth of which in the stern screw is on a line with or a little below the keel, and of a larger area, by, say 35 to 50 per cent. than the section taken on the line A.B. required for the revolution of the screw within it. The same thing would occur in the forward section or bow. Mr. Griffiths' idea with regard to the "Great Eastern," if I understand it, is this, viz., to take out the paddle-wheel engines, one set of boilers, the paddle-wheels and sponsons, and leave the centre of the ship quite clear. By removing those portions of the machinery, and putting another pair of engines forward for working a bow screw-propeller, it would give an increased cubical capacity representing some 5,000 tons addition of clear space in the midships of the vessel, and that is allowing for the room intended to be occupied by screw engines forward, and for the capacity taken out of the ship by the tunnels forward and aft. The addition made to the stern portion of the ship by these tunnels makes a difference in capacity of about 180 to 200 tons probably. One thing which seems very remarkable is that

though these tunnels would appear to be an obstruction to the forward progress of the ship they are really not so; and that has been proved over and over again by the experiments which are printed by Mr. Griffiths, particularly by the test of towing the ship by means of a line carried round a pulley. The same number of revolutions only with the same spring-power in each were required in each case, showing the duty done and the resistance offered by the model on going through the water to be the same. It thus appears that what is performed by the spring in each case during the time, is as near as possible the same as if the engines, with both fore and an after screw, were used in propelling the ship. That seemed to me to be very paradoxical, but there is no doubt that it is so, showing that the friction on the interior surface of the tube by the water passing through it, and the additional skin surface of the exterior of the tube in passing through the water, has not retarded the vessel. I think Mr. Griffiths has not alluded to that as distinctly as he might have done, but it is a very important thing as showing that these slight additions of the hollow portions of tubes added forward and aft, are not actually the obstructions which in the model they appear to be. I think one of the values to be attached to those projections to which Mr. Griffiths might have alluded, would be that in the pitching or rising and falling of the ship, they are really an advantage. That though there might be, from the fineness of lines forward, a disadvantage to have any material addition made to weight there from the leanness of the body at that part, still the retardation to the rising and falling of a ship in a seaway no doubt would be useful in keeping such vessels steady. I notice, too, that Mr. Griffiths has varied the shape of the tunnel in that stern view. He has changed the form of the tunnel to accommodate it to the lines of the ship. I believe all that is desirable is to get a larger opening at the mouth or entrance for the water, and to deliver it through an aperture not smaller than that in which the screw revolves.

Mr. PENDRED: I think it will be generally admitted that the proposition that Mr. Griffiths has brought before the world with regard to screw propellers, constituted one of the most startling proposals or theories that has yet been laid before scientific men on the subject of the propulsion of ships. Before we go into details as to the construction of the ships themselves, or as to whether they are to be weakened or strengthened, or whether Mr. Griffiths' arrangements are to interfere with the pitching and rolling, and so on, of a ship, we have to consider what Mr. Griffiths' proposition is. As I understand it, it is that he passes through the screw 50 per cent. more water than the ordinary screws take in. I may be wrong, and if so perhaps Mr. Griffiths will correct me. It does not appear to me that he has proved this proposition at all. As I look at these two models—and I believe these models are, practically speaking, identical as regards their midship section, the draught of water, weight, displacement, and driving power—the whole difference, as I understand it, between these two models is, that one may be regarded as the normal screw-ship, and on to that normal model Mr. Griffiths builds on these side pieces. If I am right, the inner portion next the keel under the counter of the ship will be precisely the same shape in both these models. Now, if we take that model as she stands, and put her into the water, it appears to me that so far from this outside casing bringing more water to the screw, we shall, on the contrary, have a less free access of water to the screw. I should like to ask Mr. Griffiths whether he has made any experiments with vessels that are peculiarly lean in the counter? As this model stands before me, it looks extremely like a vessel with very full lines, and I can quite understand if this vessel had the whole bottom filled up here, and the screw working in the ordinary place behind that, he would get a certain resulting speed, which would probably be a very slow one, and that if he hollowed out the lines, fined them off, brought them to the same condition that he has those in the second vessel, he would get a much better result. This tunnel appears to me, as regards these particular models, to bring the condition of this model with originally full lines to somewhat the condition of a model with fine lines. For my own part I cannot realize the fact that by any conceivable arrangement of tunnel we can get more water to the screw than can be got in the case of a steamer with extremely fine lines like some of our ocean vessels that Mr. Griffiths has spoken of. As regards the general results arrived at by Mr. Griffiths, I believe that they are practically indisputable, and to me they appear not only indisputable but paradoxical. I cannot

understand them, and do not pretend to do so. It is possible that if we live ten years longer Mr. Griffiths' solution of the riddle will be confirmed, but I think it is also possible we shall get at some other solution. My principal object in rising was to ask Mr. Griffiths whether he has tried these experiments with the tunnel model against models with extremely fine lines, such as we meet with in our fastest ocean steam ships.

Captain DUFF: Would not these screws be very liable to foul? Surely in any future naval engagement screws will get foul, and it would be almost impossible to clear a screw like that in a tunnel. The act of drawing water into the tunnel would infallibly draw in bits of spars and ropes, or anything that might be floating about, and the screw would be fouled completely. With regard to the principle itself, some friends of mine took a small screw steamer up the Grand Junction Canal, and they found that whenever they got through a narrow bridge, or a part where the sides of the canal were narrow, the brick-work stopped the wave that they made with the screw, and, without the engines working more rapidly, the boat travelled faster. It would be the same effect as Mr. Griffiths' tunnel, that where the water is solid the screw has more power than where the water has room to expand.

Mr. WILSON: I should like to ask Mr. Griffiths a question with reference to the model of the "Alpha" which he alluded to in the previous lecture—whether she was made in conformity with his views as to building? Secondly, I should like to ask him if I understand he proposes to put a screw and engine, in fact an entirely separate means of propulsion, in the bow and stern—whether, taking the hypothetical case of a vessel of 2,500 tons with an ordinary power of 600 horses, in his arrangement he gains any cubic capacity by two separate engines, or whether he in fact loses? He proposes to displace the engine in the middle of the ship, and to put his engines in the bow and stern. Of course he utilizes portions of the ship very little used at present, or not importantly used. He said, in his previous lecture, that he gained an enormous amount of space for the purposes of carrying cargo and passengers, by taking the engines out of the centre of the ship. The question is, what is his cubic capacity in a vessel of 2,500 tons or thereabouts, occupied by the screw as arranged in this model in the bow and stern, as compared with a vessel of about 500 h.p. with engines in the middle of the ship? It is easy to see that one means of answering the question is, that by adopting this particular arrangement of the screws he can add to the length of the ship, but at the same time he produces a draught of water. I should like to ask Mr. Griffiths whether he anticipates that by increasing the length of the ship, say to 600 or 700 feet—he mentioned 600 feet in his previous lecture—the weights ranged in the bow and stern of the ship would injuriously affect that ship if she were in ballast, as steam-ships sometimes are?

Mr. ARTHUR RIGG: It seems to me that the results of Mr. Griffiths's experiments are partly due to a somewhat similar cause whereby his original screw-propeller with an enlarged boss gave its peculiar results. In both cases any advantages obtained are partly due to what Mr. Griffiths calls "solid water." In his screw-propeller, any broken water at the centre was driven outwardly by the boss, and in the bell-mouthed tunnel it is driven inwardly, the result in both cases being identical. As to the question of solid or broken water, the latter is really water and air mixed together; and all who are conversant with hydraulic machinery are well aware that when this mixture takes place, much power is lost, and with screw-propellers in steam-ships, its presence occasions an immense loss.

In the models and drawings here exhibited, the supply for the stern screw is taken from underneath the ship, where naturally enough no air can enter, but with the usual arrangement of screw-propeller its supply comes both from above and below, and that which comes from the top, draws air with it, and so affects the propelling power; and it seems to me that one great point in this scheme is, the means whereby a supply of "solid water" is obtained.

Another point worthy of notice is that a screw-propeller is really nothing but a pump after all, and its business is to force water backwards. That this action produces progress in the ship may be seen by such vessels as the "Waterwitch," or better still, by the Thames fire engines, where a stream directed astern, whether the stream be in the air or in water, produces motion forwards, and this motion consumes power not so much in giving a movement to the vessel as by having to divide

the water in front of its bow. Thus a mass of water thrown backward is essential to progress forward.

Mr. Griffiths suggests that he might get the whole power of his engines exerted to produce a forward motion. Now I cannot see that there is ever the least possibility of such a thing coming to pass; for, as before mentioned, there is the quantity thrown backward which consumes a certain amount of power. That there is great loss at present is clear enough, and some of it may doubtless be saved, but the *necessary* loss and the *existing* loss bear a proportion to each other which is not easy to decide.

One more remark occurs to me. Mr. Griffiths says that with his two screws, one at the bow and the other in the stern, the peculiar guard found so useful with the stern screw is unnecessary. The reason of this seems pretty clear, for when both are used, the bow-screw pumps a quantity of water underneath the vessel, which naturally enough assists in supplying the stern-screw. The action of these two screws is rather advantageous in their tendency to improve a vessel's trim. The bow-screw drawing water inward and downward gives a resultant upward pressure, tending to raise the bow, while the stern-screw pumping its supply upward and astern tends to depress the stern; the two acting together, and in so far as they have any value, assisting to improve the ship's speed. Of course this is an incidental gain, which goes to make up the benefit found to exist by Mr. Griffiths in his interesting and remarkable researches and experiments.

Captain SULLIVAN, R.N.: I should like to ask Mr. Griffiths how he intends to form that screw—how to construct it? If that part which forms the tunnel is one solid piece the whole length of the ship, it must be detached from the rest of the tunnel itself. How would the joint be formed in the tunnel in building the ship? It strikes me if that ship struck the ground the tunnel would go to pieces.

Mr. GRIFFITHS: I think the first question asked was as to the power required. I explained that with the screw at the stern in the ordinary way in open water the model will make 632 revolutions and give 59 feet; that is the average of several trials. With the bow-screw in front of the sternpost in open water I shall get 45 feet 6 inches with 618 revolutions. If I put the bow-screw in the bottom discharge tunnel with 638 revolutions she will give me 62 feet 6 inches speed. Then if I put this bell-mouth on to it, so that there is 50 per cent. extra supply of water, she will give 71 feet 7½ inches. If you cube those two speeds it will be 226,981 for the 61, and 357,911 for the 71, which shows equal to nearly half the power difference. If I put the screw outside the bow (here is the thing that has never been known) in the open water I get 45 feet, but if I put a little casing round it I get 58 feet 7½ inches. The supposition has been that the loss in the bow-screw was in driving the water towards the bow; it does not appear to be so at all. I shall put that same screw and she will get as good a result, but when I take this casing off she gets about half the result. I believe the Admiralty and others have tried a casing round the screw at the stern, which did not prove satisfactory. If I put this casing round the screw there I shall only get 48 feet with the same revolutions instead of 58. Then the screw at the stern in open water, with half casing below it three times the length of the screw, only gives 36 feet; but if I put that half casing over the top I get 58 feet 2 inches. These are things no one had imagined before,—the simple fact of whether you put that casing below or over the screw makes all that difference. It shows clearly that all the water to supply the screw comes from below, and that it is the bottom part of the screw that does the work. Then I tried them with full power. With twin screws I got 81 feet. I put the screw at the bow and stern in open water and got 87 feet. Then I put the bow-screw and side discharge tunnel (as fitted to the "Alpha," at Lynn) and the stern-screw in open water and I got only 84 feet with the two. Then I put the screw in the bow bottom discharge tunnel and the stern-screw in open water, then I got 96 feet. Then I put the two screws in bow and stern bottom discharge tunnels and I got 101 feet 6 inches. If you cube that speed I have nearly got a speed due to double the power, and that is a saving of nearly one-half the power. Then I took the full power on a single screw, and the model of a ship with the screw at the stern in the ordinary way, it gave 78 feet 6 inches, and the screw in the bottom discharge bow-tunnel gave me 80 feet 8 inches. A single screw with double power will give me just as the cube,

but if I have two and put them in the tunnels it gives us the square. That is the whole secret of it. This ought to open everybody's eyes as to screw propulsion. The following experiments were made to ascertain the effect of the screw with various supplies of water. The pitch of the screws was $3\frac{1}{2}$ inches in all the experiments. In the model of a ship with the screw at the stern in the ordinary manner; with 636 revolutions, she went 58 feet; with a disc placed before the screw $1\frac{3}{8}$ in. diameter, the speed was reduced to 48 feet and the revolutions to 582. I increased the disc to $1\frac{15}{16}$ in. diameter and the revolutions were reduced to 565 and the speed to 28 feet; with a disc $2\frac{3}{8}$ths diameter the revolutions were reduced to 550 and the speed to nothing—the boat stopped. Then I increased the diameter of the disc to $2\frac{3}{4}$, the model went slightly back and the revolutions were reduced to 485. The same spring was doing the work. I tried it again in the tunnels. The first disc was $2\frac{3}{4}$ in. diameter, the same size as the tunnel, allowing no water to the screw. The springs could only get to 372 revolutions; the model never moved. I reduced it to $2\frac{1}{2}$ diameter and the speed of the engines rose to 412, while the boat moved 6 feet. I reduced it to $2\frac{1}{4}$ inches, the revolutions rose to 465 and the model moved 7 feet. I then reduced it to 2 inches diameter, the speed of the engines rose to 490 and the model went 9 feet. I then put a disc of $1\frac{3}{4}$, the revolutions were 565 and the model moved 26 feet. I then put a disc of $1\frac{1}{4}$ in., allowing 5 inches area for the water, the revolutions were 585 and the model went 52 feet. With disc, allowing 6 inches area, that is the whole area, the model went 62 feet with 600 revolutions. Then I enlarged the mouth of the tunnel, giving $7\frac{1}{2}$ inches water area, the engines made 613 revolutions and the model went 69 feet. I increased it again to $8\frac{1}{2}$ inches, the power went to 630 and the model 70 feet; with $9\frac{1}{2}$ inches the power was 618 and the distance 69 feet. That shows as clearly as anything can show that it is entirely depending on the supply of water, but as you reduce the supply of water your power increases to drive your screw. The bell-mouth need only be used when only one screw is required; it is of no use when you have screws at each end. If this model is going at the rate of 60 feet, and I add this bell-mouth, it will go 70 feet. There is a greater force of water going through, but my engines are working the same number of revolutions and the pitch of my screws is the same. We found in the "Alpha," that when we disconnected the bow-screw and drove the boat with the stern-screw, the bow-screw revolved just as much as was due to the speed the boat was going at, but if we disconnected the screw at the stern she only went at about one-third of the speed.

A question was asked, how the tunnels are strengthened? I contend that the ship is considerably stronger by this mode of building. It is no detriment whatever to stiffen this tunnel by bars across or with a grating in front; it does not stop it up at all. If I put these reactionary blades behind the screw, I get rather a better result, as I get solid water for the screw to work in, though not to the extent of making much difference. It shows that when the water has once gone through the screw, it is very little consequence what it comes in contact with; all that is wanted is to get the water on the forward side of the screw. Therefore, if I were to put a grating in front, or bars to stiffen this aperture, it does not affect the result of the propeller at all. One gentleman asked a rather important question with regard to the two engines. The present system of screw propulsion has been carried to such an extent that the engines are made of such a magnitude that they can hardly make castings strong enough to stand the work. Instead of having those enormous engines and the vibration from them in one part of the ship, if you divide the single engine into two and place it as far back in the stern and as near as you can to the bow, there is then no loss of stowage, you get all the best part of the ship for stowage, and the weights are more regularly placed than by putting them in one part of the ship altogether. The great advantage is that in case you break down with one screw, you have the other left to work with. How often is it the case that the screw or the engine is damaged, and the ship is for weeks knocking about, rocking to and fro in the trough of the sea, and as soon as the cargo shifts, down she goes. If you break down with one screw, you are just as safe; and you get two-thirds of your speed to the end of your journey.

Mr. WILSON: How about the ship in ballast with her midship section empty?

Mr. GRIFFITHS: You would ballast the same as usual.

Mr. WILSON: Do you think that would be sufficient?

Mr. GRIFFITHS: You might as well have your ballast here as there—what difference will it make? The ship is as stiff if you put your weights down here. Now look at a ship pitching. When she is pitching, the screw is up and racing away tremendously. In my vessel we know when one screw is out the other must be well immersed, consequently you do not lose speed; whereas if you are pitching, having only one screw, you lose momentum. We hear a great deal about slip; now it is the greatest nonsense that was ever talked in the world. They calculate the slip as if the screw is working in a solid, and to suppose for an instant that the ship is propelled by that screw without moving water through it at all, is all nonsense. There is always from 50 to 60 per cent. of slip in the best screw ever made. I had an order from the Admiralty to make a screw for the "Flying Fish," a good many years ago. I was told that there was an enormous quantity of slip. I said "I did not believe it was "slip, but if it was believed to be slip, I would send a couple of blades for the screw "and they would drive the ship without any slip at all, but I did not say that it would "drive it any faster." I sent with the screw another pair of blades cast from the same pattern, the only difference being that instead of the blades being at right angles with the shaft, they leaned towards the ship at an angle of about 30°. My screw was first put in at 20 feet pitch, and there was not much difference in the speed from the former screw; but there was less vibration. When the experimental blades were put in at 16 feet pitch, the engines could not get the speed out of her, and she showed actually, with one screw, 20 per cent. slip, and with the other a negative slip, but not quite as good speed to the ship. It is very strange that it never has been noticed, and whenever anybody talks to me about slip, I put it down that that person knows nothing about the screw. As to fouling the screws, you would put bars across the entrances to the tunnels, and they are completely protected.

Captain DUFF: I suppose if you did get the screws foul, you would never get them clear again. It is very difficult to get at your screw.

Mr. GRIFFITHS: I think they would be far better protected than on the ordinary plan. It is a great thing to get them cased. Anything that fouls the screw generally floats near the surface, it does not go underneath the ship.

The CHAIRMAN: I dare say there may be some differences of opinion amongst so many of us as to this contrivance of Mr. Griffiths. It is such a novelty, that we cannot form any very decided opinion upon it at present. I certainly cannot. I am inclined to look to the results, and to think that, according to the old proverb, "the proof of the pudding will be in the eating," for if those results which Mr. Griffiths has found in the models, can be attained in sea-going ships, it will be of considerable importance. Some of the objections are rather to be tested in practice than to be argued upon. Certainly the results brought before us are most startling, and we shall be very glad to see practical results on a larger scale. Whether we agree or not with all the details that Mr. Griffiths has brought before us, we may, at least, agree in thanking him very much for his lecture this evening.

Note.—Since reading the above paper, I have made further experiments of considerable importance to steam navigation by elongating the stern-tunnel and either putting two screws, on the shaft, within the tunnel, the after screw having 20 to 30 per cent. greater pitch than the foremost screw, or by making one long screw with increasing pitch; I thus obtain even a better result than by dividing the power between the bow- and stern-screws, as shown in the paper. This system can readily be adopted in all existing screw-ships with but slight alterations; and no alterations to the engines and screw-shaft are required.—R. G., 4th June, 1874.

Evening Meeting.

Monday, March 30th, 1874.

VICE-ADMIRAL SIR FREDERICK W. E. NICOLSON, Bart., C.B., Vice-President, in the Chair.

NAMES of MEMBERS who joined the Institution between the 3rd and 30th March, 1874.

LIFE.

Bousfield, N., Major 1st Lancashire Rifle Volunteers, M.P.
Milne, Archd. B., Mid. R.N.
Beresford, C. E. de la P., Lieut. 46th Regt.
Cole, Joshua, Lieut. R.N.
Olive, Ernest L., Lieut. 38th Regt.
Ewart, J. H., Lieut. 78th Highlrs.
Ferris, John, Lieut. R.N.
Yeatman, A. G., Captain R.A.
Vesey, Hon. Eustace, Sub.-Lieut. 9th Lancers.

ANNUAL.

Martin, James J. S., Surgeon R.N.
Lindoe, F. E., Lieut. 81st Regt.
Arbuthnott, Hon. Hugh, Lieut. 81st Regt.
Satterthwaite, B. A., Lieut. 81st Regt.
Stebbing, F. A., Captain h.-p. 8th or King's Regt.
Bishop, H. P., Lieut.-Colonel R.A.
McKean, A. C., Lieut. Innis. Dragoons.
Tynte, Mervyn, C. S., Lieut. 4th Drgn. Guards.
Nesham, T. P. W., Lieut. R.N.
Bailey, T. J., Lieut. 3rd Sikh Infantry.
Bowles, A.M., Lieut. 95th Regt.
Carfrae, C. W., Lieut. 78th Highlrs.
Bromfield, James, Lieut. 50th Regt.
Lawrence, W. W., Lieut. 18th Royal Irish Regt.
Gaskell, J. F. U., Lieut. 6th Dragoon Guards.
Grant, Arthur H., Lieut. 27th Regt.
Tritton, H. J., Lieut. 25th Surrey Rifle Volunteers.
Baynes, W. W., Dep. Insp.-Gen. of Hospitals and Fleets.
Ewart, R. W., Lieut. Scottish Borderers Militia.
Bircham, A. H., Lieut. 60th Roy. Rifles.
Bowles, H. C., Lieut. Rifle Brigade.
Bevan, G. B., Captain 81st Regt.
Marriott, C. F., Capt. 6th Drag. Guards.
Barton, Hugh M., Lt. late 17th Lancers.
Copeman, C. R., Capt. 1st Lanc. Rifle Volunteers.
Purvis, J. C., Captain R.N.
Campbell, A. H., Lieut.-Col. late Bengal Staff Corps.
Bloxam, Geo. W., Captain 3rd Carmarthen Rifle Volunteers.

RECENT IMPROVEMENTS IN THE MANUFACTURE OF PEBBLE-POWDER.

By Major J. P. MORGAN, R.A., Assistant Superintendent, Royal Gunpowder Factory, Waltham Abbey.

I HAD the honour of being asked last year by the Council of this Institution, to give a lecture on "pebble-powder;" but the subject—which is a very difficult and complicated one—at that time not appearing to me to have been thoroughly worked out in all its details, I begged to be allowed another year for further considera-

tion. I may not even now be able to give a completely satisfactory solution of the whole question, but I hope to bring forward a good many facts connected with the manufacture of pebble-powder, and thus give a tolerably fair idea of the state of matters up to the present time.

The points to be attained, as is well known, in any improvements in the manufacture of powders, are an increased velocity of projectile, a diminished strain on the gun, and greater uniformity of results. It was the introduction of heavy and rifled guns that drew attention to the importance of these points, and we accordingly find that as the size and precision of fire of guns have increased, the necessity for improved gunpowder has been felt in all countries. In a paper read here in 1871,* I entered very fully into the methods which have been used for determining the explosive force of gunpowder, showing that it is to Captain Rodman, of the United States' Army, that we are indebted for having first taught us how the pressure of gunpowder may be measured in the bore of the gun in which it is fired. This is the only satisfactory way of solving the question, and we accordingly find that his experiments led to the discovery that the means of moderating the rate of combustion of gunpowder lay not only in increasing the size of the grain, but also in increasing the density. Thus originated the American mammoth and perforated cake powders, which have since found their way in modified forms into all countries where the art of powder-making has advanced. The prismatic powder, which has been adopted in Russia and Prussia, is derived from the American perforated cake, and the mammoth powder has appeared in Belgium as "*Poudre à gros grain*," and is slowly making its way into France, Italy, and other continental countries. It has been imported into England under the name of "pebble-powder."

As early as 1858, a Special Committee on gunpowder was appointed under the presidency of Colonel Askwith, then Superintendent of the Royal Gunpowder Factory, Waltham Abbey, and their investigations resulted first in the introduction of R.L.G., and afterwards in the recommendation of "pellet-powder" for heavy guns. In their final Report in 1866 they recommended that extensive and systematic experiments should be carried out with the latter powder. They also tried experiments with a pebble-powder which then went by the name of 2 A 4. It was made at Waltham Abbey, in imitation of the American mammoth powder, by breaking up press cake with copper hammers, and sifting the pieces between meshes of 1 and 2 to the inch. The effect of density in modifying the action of powder was overlooked, and this powder when fired in the B. L. guns was found not only to destroy the vent-pieces, but also to enlarge the chambers of the guns, the latter circumstance showing that the fault lay not in the guns but in the gunpowder. It differed from the American mammoth in one very important respect, being only 1·62 instead of 1·82, which is the American density for both cannon and mammoth powders. It is unfortunate that further experiments were not tried with higher densities, as it is probable that thus we should have had our pebble-powder much sooner than has been the

* On "The Determination of the Explosive Force of Gunpowder," see Journal, vol. xv, page 312 *et seq.*

case. The importance of density, however, was not at that time so well understood as it now is, and there appears to have been a bias on the minds of some of the members of the Committee in favour of regular grains pressed separately in moulds, which process they considered also could be carried on more economically than the granulation of 2 A 4 powder, where there was a great amount of waste.

The introduction of the mercurial densimeter at a later period allowed the question of density to be more satisfactorily dealt with. This instrument was first designed in France, and was used for some time in the Chemical Department, Royal Arsenal, before it was introduced into the Royal Gunpowder Factory at Waltham Abbey in 1869.

The present Committee on explosives under the presidency of Colonel Younghusband, Superintendent, Royal Gunpowder Factory, Waltham Abbey, was appointed in 1869, and conducted an extensive series of experiments with various powders by methods similar to those used by Rodman, which led them to the conclusion that pebble-powder was better suited to the requirements of the service than pellet-powder. As it is also now very much easier and safer to manufacture, the change they recommended from pellet to pebble is not to be regretted. It is to the slow and steady progress in the manufacture of this powder that I propose to direct your attention this evening. In doing so, it seems to me that I shall be best able to acquaint you with the subject by giving a short historical sketch of the process as carried out at Waltham Abbey, and, as far as I know, by those merchants who have supplied pebble-powder under contract. You may depend upon the facts I adduce; but I may caution you against accepting too readily the conclusions I draw, because I know no subject where hasty conclusions are so apt to be overthrown as is the case with the manufacture of pebble-powder.

The first specification sealed to govern the manufacture was 16/5/70, the density being 1·8, the size of grain between $\frac{3}{8}$ and $\frac{1}{2}$ inch, and when fired in the 8-inch gun the velocity between 1420 and 1480 f.s., and the pressure in no case to exceed 20 tons in the bore of the gun, as indicated by the "crusher" gauges in use by the Committee. Soon afterwards, however, it was found that there was a difficulty in maintaining the velocity, and the specification was altered as regards density, with a view to meet the requirements of the case, being lowered to 1·765 in August the same year. Some powder had been made having a density of 1·8, but it was kept in reserve, and afterwards mixed with pebble having a lower density, so as to give a mean of 1·765. The manufacture was continued at this density, and as the proof in the 8-inch gun was satisfactory, it was imagined no further difficulty would be experienced.

The method at first adopted of breaking up the press-cake into pebbles was the same as that described for producing the 2 A 4 grains, viz., the use of copper hammers. This is manifestly a very tedious and troublesome process. It is still, however, to be seen in operation at the Wetteren Factory, in Belgium, where the cake is first cut into strips by a sort of guillotine machine, and afterwards broken up in this

fashion by means of wooden mallets in a hollow hemispherical bowl, into pebbles.

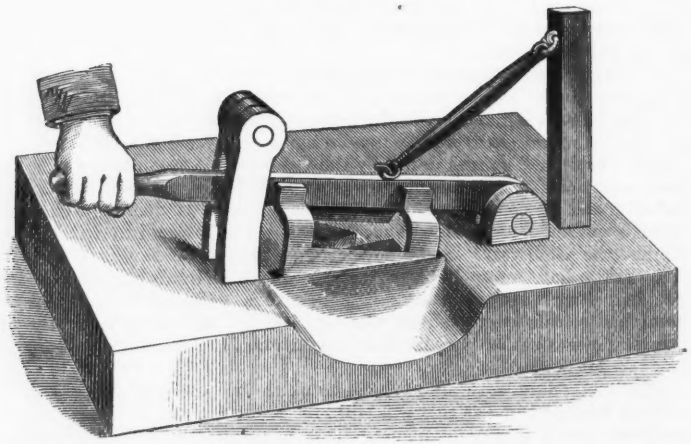
A system of chopping up the cake by means of copper knives very soon superseded the method of breaking up by hammers at Waltham Abbey. The cake was first cut up into strips by the knives, and these strips were again chopped across into pebbles by the same instrument. It was, of course, a tedious process, but it had the advantage of making little or no waste, and nearly the whole of the press-cake could thus be converted into grain.

A good many experiments were tried with a view to granulate the pebbles in the same way as ordinary powders, but all the attempts were very unpromising, owing to the irregularity of the grains and the great amount of waste. Messrs. Curtis and Harvey, however, produced a large proportion of their pebble-powder supplied by contract in this manner. They only, I believe, however, obtain about 30 per cent. of grain from their cake, and though this low percentage does not inconvenience them, inasmuch as they can find other uses for the smaller grains, it would not do at a Government factory, where there is no other use to which they could be applied.

The chopping-knife was in operation for a considerable time, and turned out the whole of the pebble manufactured at Waltham Abbey from August, 1870, to May, 1871, during which time about 4,000 barrels of 125 lbs. each were manufactured and sent to Purfleet.

The following woodcut will serve to give an idea of the nature of these instruments :—

FIG. 1. Scale $\frac{1}{6}$.



One man could thus cut about 150 lbs. a day, so that the granulation of pebble-powder at that time required the continual employment of

nearly 20 men for the very small out-turn of about 100 barrels a week.

The following extracts from the proof books will show the nature of the powder manufactured at this time:—

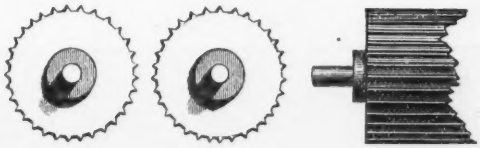
Brand of powder.	Density.	Date of experiment.	Number of experiment.	Muzzle velocity.	Pressures in tons.		
					A.	B.	C.
15/10/70	1·761	27/10/70	357	1460	17·1	18·1	16·3
14/11/70	1·765	8/12/70	367	1446	18·1	18·0	15·6
31/12/70	1·757	1/2/71	389	1409	15·4	15·4	14·6
21/1/71	1·759	1/2/71	392	1409	12·6	13·1	12·1
3/2/71	1·761	20/3/71	408	1405	14·1	14·2	13·9
25/3/71	1·759	5/4/71	440	1406	15·5	15·0	14·8

It will be observed that there is a steady decrease in the velocity at proof. Some of the velocities are even lower, but these samples give an idea of the general average of the work produced at this time.

Meanwhile experiments were being carried on with a view to turn out pebbles in larger quantities and more economically than by the tedious process of chopping up with knives. My predecessor, the late Captain Smith, R.A., hit upon a plan which was very successful in doing the same sort of work.

This was by making a succession of knives come into operation one after the other, by being arranged longitudinally on the circumference of two long rollers in the following fashion:—

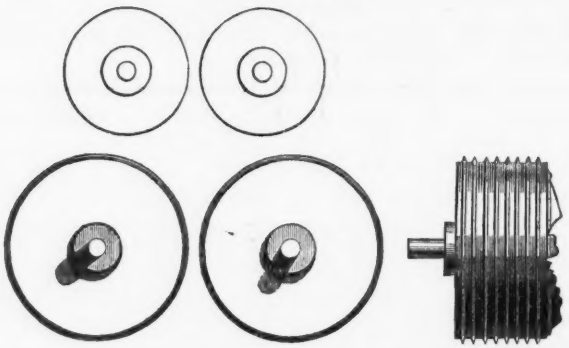
FIG. 2. Scale $\frac{1}{12}$.



The cake was thus very rapidly cut up into strips, but in putting the latter through the second time endways much time was lost, as each strip had to be picked up separately by hand before being put through. He contemplated having a second pair of rollers of the same description as the first, for the strips to pass through, but was unable to devise a method of conveying them from the first to the second pair of rollers, and so his plan for a time remained in abeyance.

Colonel Younghusband thought that the strips could be conveyed, as they passed the first pair of rollers, in succession to a second pair, which had the knives arranged circumferentially instead of longitudinally, as shown in the following woodcut:—

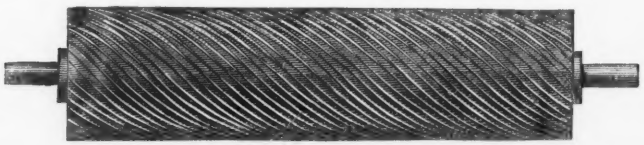
FIG. 3. Scale $\frac{1}{12}$.



He found, however, that the strips would not drop horizontally on to the second pair of rollers, but that they dropped as often endways as sideways, and generally that they fell in all directions, owing to the uneveness of the press cake from which they were cut.

Mr. Pigou, of Pigou and Wilks, designed a very ingenious pair of rollers, which performed the work of cutting up the cake into pebbles in one operation. Both rollers were identical and had the knives arranged, neither longitudinally nor circumferentially, but spirally, at an angle of 45° round the surface. The knives thus crossed each other perpendicularly at the cutting points, and very tolerable granulation was effected. The pebbles, however, were very irregular in shape, and by no means so cubical as those cut up by knives. The following woodcut of Mr. Pigou's roller is given to show the nature of the arrangement:—

FIG. 4. Scale $\frac{1}{12}$.



It had hitherto been supposed that, the more uniform the size and shape of the grain, the better would be the results at proof; but while Waltham Abbey pebble seemed to be failing at proof, Mr. Pigou's pebble gave very good results, as shown by the following experiment:—

Powder.	Density.	Experiment.		M. V.	Pressure.		
		Date.	No.		A.	B.	C.
Lot 826	1·765	28/3/71	428	1460	16·5	16·4	15·8

I have stated my intention of describing the manufacture of pebble-powder as I have learned it myself, and I may here say that this was the position of affairs when I was appointed Assistant Superintendent in succession to Captain Smith. I hope I have succeeded in convincing you that the manufacture of pebble-powder is a great mystery; at least so it appeared to me.

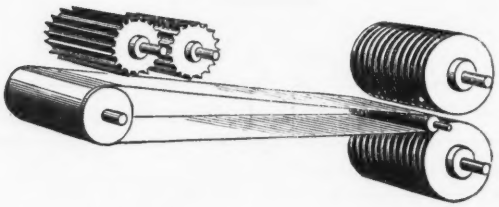
It seemed a tolerably easy matter to turn out powder, but to make it produce the desired results in the 8-inch gun, so as to pass the specification, was quite another affair.

I suggested to Colonel Younghusband that it seemed very probable that the fact that Mr. Pigou's sample consisted of irregularly shaped grains was the reason why he obtained a better velocity than could be obtained with the Waltham Abbey regular cubes, because the irregularly shaped grains would present larger surfaces for initial ignition. It would not do to use small grains, because they would interfere with the passage of the flame in igniting the charge; but there could be no objection to large irregularly shaped grains. Colonel Younghusband tried the experiment, and used the larger rollers in an ordinary granulating machine to break up press cake into irregular grains. This was mixed with knife-cut pebbles, and, on firing a sample of the ordinary work in comparison, the following result was obtained:—

Stoving.	Density.	Experiment.		M. V.	Pressures.		
		Date.	No.		A.	B.	C.
25/4/71	1·770	2/5/71	483	1399	16·9	16·6	15·6
25/4/71 Granl. P.	—	2/5/71	485	1436	19·4	19·3	19·7

It seemed to me that, in Colonel Younghusband's machine, the strips might be made to rectify themselves by being allowed, in the first instance, to drop on a canvas band which, as it travelled, would convey each strip forward so as to allow the next to drop behind it, and afterwards convey the strips in succession in the proper position to pass through the second pair of rollers as follows:—

FIG. 5. Scale $\frac{1}{20}$.



This plan was tried, and was found to answer quite successfully. A very simple machine thus constructed was in operation from the end of May, 1871, to March, 1872. The following is the proof of the first sample turned out by this machine:—

Stoving.	Density.	Experiment.		M. V.	Pressures.		
		Date.	No.		A.	B.	C.
19/5/71	1·768	24/5/71	534	1475	20·9	20·3	20·0

It will be seen that the velocity and pressure are both high, which is no doubt due to the fact that the pebbles turned out by this machine were smaller than the hand-cut pebbles. The results obtained, however, seem to meet the requirements of the case, especially as the out-turn of the machine was only about 40 barrels a-day. The capabilities of the factory in the other processes of manufacture are much greater, and so the chopping process was continued, and the pebbles produced by both processes were mixed together and the total out-turn increased from about 100 barrels to nearly 300 a-week.

Colonel Younghusband tried an experiment to compare directly the work produced by hand-cut and machine-cut pebbles, not only with the ordinary work of the factory, but also with work which had been milled with an increased amount of moisture in the charges, with the following results:—

Stoving.	Density.	Experiment.		M. V.	Pressures.		
		Date.	No.		A.	B.	C.
OK. 2/6/71	1·768	10/6/71	549	1440	19 4	19·8	18·6
HK. 2/6/71	1·782	10/6/71	550	1444	16·7	15 6	16·3
OM. 7/6/71	1·787	16/6/71	570	1445	19 7	17·4	16·6
HM. 7/6/71	1·782	16/6/71	579	1437	19 6	18·8	18·0

It will be seen that there is not very much choice, but that on the whole the charges worked "heavy," or with the increased percentage of moisture, produce the best results. The more moisture in the powder the less is the danger arising from an explosion in the mills, and the charges were accordingly afterwards worked heavy.

All stovings are proved in the 8-inch gun, and those which meet the required tests are at once "branded," and passed into the service.

The others are mixed in a manner calculated to produce the required results. The velocities and pressures obtained at proof were always a matter of considerable uncertainty. I may compare our various stovings to different vintages of wine. We had an uncertain control over our stovings, but after proof we were able within certain limits to produce any brand required.

A regular systematic mixing had to be established so as to work off and send away the manufactured powder as speedily as possible after proof. At first the stovings were mixed, in a rough and ready way, by two men each taking a barrel and alternately pouring a small portion of the contents into another barrel, but very soon a more methodical and satisfactory plan was established.

It appeared to me that, in order that our mixing should be a success, some plan must be adopted of securing that each stoving itself should be perfectly uniform. It appeared vain to attempt to work to densities, for, from the samples already given, it will be seen that density taken alone is no criterion of what may be expected at proof. A mechanical system of mixing seemed to promise the best results, and this plan was adopted. In order to do this with as little trouble as possible, advantage was taken of some of the processes of manufacture.

A glazing as a rule consists of four large barrels or churns, each of which contains about four small barrels of powder. As these churns revolve at 37 revolutions a minute for four hours, it may safely, I think, be assumed that the contents of each churn are well and uniformly mixed. It by no means follows, however, that the contents of one churn are of the same character as those of the others.

The next process is the stoving, and advantage is taken of the method of setting the stove to make the whole of one glazing perfectly uniform. The powder is set in trays, each tray containing four bowlfuls, or about 16 lbs. In filling a tray, a bowlful is taken from each churn, and thus every tray of a glazing contains exactly the same powder. The glazings are marked off separately in the stove. After stoving, the powder is finished by being revolved about 20 minutes in reels which contain four barrels each, and, as the stove contains four glazings, this gives the required facility for making the whole contents of a stove uniform, because into each reel can be put one barrel from each glazing. I know no process which has been attended with greater certainty in producing uniform powder than this system of mechanical mixing. It gives no extra work, and requires only a little care and attention on the part of the workmen.

Though each stoving, however, is perfectly uniform, it will be seen by the following proofs that different stovings are by no means of the same character. These stovings are selected as giving as near as

possible an average of the work turned out, some being higher and some lower as regards velocities and pressures.

Stoving.	Density.	Experiment.		M. V.	Pressures.		
		Date.	No.		A.	B.	C.
26/6/71	1·772	14/7/71	648	1461	21·4	21·6	19·4
30/6/71	1·792	5/7/71	627	1332	11·5	11·1	11·0
10/7/71	1·792	14/8/71	59	1385	14·4	14·2	13·8
29/7/71	1·763	7/8/71	38	1507	22·8	20·7	20·0
9/8/71	1·758	18/8/71	80	1400	14·6	15·0	14·4
18/8/71	1·776	25/8/71	101	1442	17·8	17·5	16·6
28/8/71	1·777	6/9/71	134	1408	16·3	16·2	15·0
1/9/71	1·784	6/9/71	137	1358	13·3	13·4	13·4
26/9/71	1·762	9/10/71	225	1436	18·4	18·3	17·1
3/10/71	1·753	13/10/71	253	1440	17·2	17·2	16·7
18/10/71	1·765	27/10/71	298	1438	18·5	19·2	17·1
1/11/71	1·768	9/11/71	336	1428	16·1	16·3	16·4
13/11/71	1·736	23/11/71	375	1469	17·4	18·4	17·8
16/11/71	1·735	23/11/71	377	1512	19·9	21·2	21·0
17/11/71	1·736	23/11/71	378	1534	25·1	24·9	23·5
17/12/71	1·750	15/12/71	459	1438	14·8	16·2	16·1
15/12/71	1·750	2/1/72	501	1396	13·3	12·3	12·8
28/12/71	1·755	3/1/72	524	1391	15·1	14·3	14·4

It will be observed that, though a good many of these stovings are within the limits of the specification, some are very much too low in velocity, while others are too high, both as regards velocity and pressure. Those stovings which were too high in velocity or pressure were mixed with others which were of low velocity and pressure, so as to give a mean result within the specification. This was attended with little inconvenience, as long as the mean results of proof fell within the specification, but it was rather troublesome when there was a long series of proofs of the same character. Some of the proofs it will be observed are either exceptionally high or exceptionally low. With regard to stoving, 30/6/71, I find the following note in the proof-book, in Colonel Younghusband's handwriting:—"1,000 grs. sample of this "powder was dried by Mr. Abel for five hours, at 200° Fah., resulting "in a loss of 0·33 per cent., proving that the very low velocity was not "caused by moisture."

Stovings 16 and 17/11/71 call for special remark. Every inquiry was made as to the possible cause of the low densities and high pressures and velocities, but nothing could be traced, excepting that the chief foreman believed that the charcoal had been overburnt. As this fact at the time was thought calculated to produce the opposite effect, the real cause appeared to be a mystery.

The change from the old to the new gun does not appear to make much difference, as it will be observed that there are low velocities with the new as well as with the old. This latter point was not, how

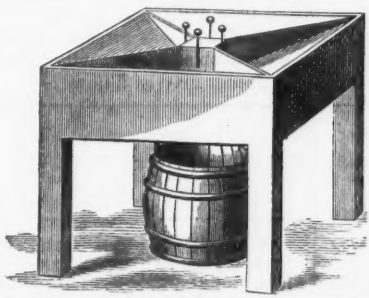
ever, left purely to speculation, for Colonel Younghusband tried identical samples in both guns, with the following results :—

Stoving.	Density.	Experiment.		M. V.	Pressures.		
		Date.	No.		A.	B.	C.
26/6/71	1·772	14/7/71	647	1460	21·5	20·6	18·5
Ditto	Ditto	Ditto	648	1461	21·4	21·0	19·4
5/7/71	1·789	12/7/71	638	1368	13·6	13·5	13·0
Mean of above, mixed, 2 to 1..	..	..	..	1436	18·8	18·4	17·0
Ditto, 2 to 1 in old gun	..	14/7/71	650	1420	18·9	17·6	16·5
			652	1450	19·5	19·5	18·1
			653	1454	20·4	19·8	18·7
Ditto, 2 to 1 in new gun	..	31/7/71	7	1439	17·6	17·2	16·3
			8	1453	18·7	18·9	17·9
			9	1449	19·8	19·8	18·1

The plan of mixing the stovings, as I have stated, was at first by hand, but towards the end of 1871, a four-way hopper was made, which materially assisted this process. Sometimes the stovings were mixed two and two, and sometimes four and four, according to the circumstances of the case.

The following woodcut will give an idea of this hopper :—

FIG. 6. Scale $\frac{1}{10}$.



I have brought the manufacture at Waltham Abbey down to the end of 1871, and it will be observed that the old tendency to low velocity again begins to manifest itself; and, as this tendency appeared on the whole rather to get worse than better, it began to become troublesome. Not only at Waltham Abbey did it show itself, but in nearly all the powder sent in by the merchants by contract. Lot after lot manufactured by Messrs. Curtis and Harvey, and by the Kames Company especially, showed the same failing; and the question of the manufacture of pebble began to look serious.

The new year, however, introduced a new era. A sudden fit of inspiration seized Colonel Younghusband, and he ordered two samples to be restoved. Behold the result:—

Stoving.	Density.	Experiment.		M. V.	Pressures.		
		Date.	No.		A.	B.	C.
10/1/72	1·765	24/1/72	605	1398	15·8	15·5	14·8
Ditto re-dried	—	31/1/72	677	1455	20·9	20·3	18·5
12/1/72	1·763	24/1/72	606	1367	13·8	13·8	13·8
Ditto re-dried	—	31/1/72	678	1418	15·6	13·6	14·6

It was a great relief to have discovered the reason at last. Doubtless some will think it was very foolish not to have discovered it sooner; but I hope they will suspend their judgment till they have heard the whole state of the case. Meanwhile I will observe that the cause had been suspected, and, as I have stated, a sample sent to the Chemical Department for analysis, showed a very small loss of moisture. The powder had received the usual amount of stoving. But, what is of more importance is, that when the discovery was communicated to the merchants, with a view to assist them out of their difficulties, one and all refused to believe it.

At Kames an experiment was made to test the matter roughly, by weighing a large sample before re-stoving, and weighing it again afterwards, and, as only a slight difference of weight was detected, it was concluded that the fault of Kames' powder did not lie in its insufficient drying. An experiment was afterwards made at Waltham Abbey, with some of Kames' pebble, which partly bears out the result. Two samples were re-stoved, and fired as follows:—

Brand of Powder.	Density.	Moisture.	Experiment.		M. V.	Pressures.		
			Date.	No.		A.	B.	C.
Lot 86.....	1·772	1·17	21/5/72	964	1338	16·1	16·1	14·8
Do., re-dried.	—	·898	7/6/72	1030	1394	19·3	17·6	17·0
Lot 97.....	1·755	1·14	21/5/72	968	1336	16·2	16·4	15·0
Do., re-dried.	—	·816	7/6/72	1031	1379	18·2	18·5	15·8

It will be observed that in the original samples there is no excessive amount of moisture, but rather under the normal amount, if anything, and the re-dried samples may be considered over-dried.

The discovery of the great effect of moisture on velocity and pressure opened up a very large question, and threw discredit to some extent on all the experiments which had hitherto been made, seeing that it could not be told to what extent all the results had been vitiated by an

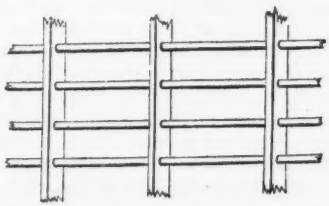
unknown amount of moisture which existed in the samples fired. It at once explained why there had been so much low velocity powder a year before, and there can be no doubt that, had the reason been known in time, it would have been better to have re-dried some of the powder which had been mixed.

The manufacture continued as before, with varying results; sometimes the proofs were right, and sometimes they were too low, in which case they were re-dried, or mixed with others that were too high.

Stoving.	Density.	Experiment.		M. V.	Pressures.		
		Date.	No.		A.	B.	C.
8/2/72	1·756	15/2/72	710	1427	18·8	17·5	16·5
21/2/72	1·754	29/2/72	739	1478	17·9	18·2	17·3
4/3/72	1·762	7/3/72	778	1389	16·4	15·6	15·8
Ditto, re-dried ...	..	13/3/72	..	1466	18·1	18·6	18·0
23/3/72	1·762	8/4/72	900	1430	20·3	19·1	17·8

The last sample it will be observed, shows a falling off in the powder, and the reason is to be explained as follows. A new machine on Colonel Younghusband's principle had been made, and had just then come into operation. It turned out such a large quantity of pebble that we could now dispense with the more expensive process of cutting by knives. The machine was calculated to give pebbles as large as with the knives, but evidently there was a fault somewhere. On examination I found that there were a great number of flakey pebbles, of the description of cubes, divided down the middle. They thus were in length and breadth of the proper dimensions, but in thickness only half of what they ought to be. This I considered to be due to the faulty principle of the second pair of rollers, which did not allow of the strips extending outwards, as they were being cut. Though they were very detrimental to the proof of the powder, they could not be removed by the ordinary method of sifting. I succeeded in removing them, however, by the device of an oblong mesh of the following pattern:—

FIG. 7. Scale $\frac{1}{2}$.



When being sifted, the flakey pebbles tilted on their edges, and

passed through while the ordinary pebbles were retained. It was found that the system of re-drying was rather troublesome, as it occupied the stoves frequently, when new powder was required to be dried; and, as 36 hours' drying could be given without extra inconvenience, the time of drying was increased on 1st April, 1872. to 36 hours, at the old temperature of 125° Fah. The following are some of the proofs :—

Stoving.	Density.	Experiment.		M. V.	Pressures.		
		Date.	No.		A.	B.	C.
12/4/72	1·756	19/4/72	815	1428	17·6	18·2	16·3
22/4/72	1·752	26/4/72	923	1455	21·8	21·8	19·6
10/5/72	1·772	17/5/72	937	1408	15·2	15·3	14·8
Ditto re-dried	—	29/5/72	1002	1507	21·6	21·2	17·7
13/5/72	1·777	17/5/72	940	1452	15·3	14·9	14·1

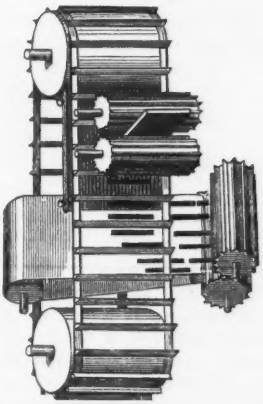
The last shows a considerable improvement over the others, being due to a great extent to the fact that a sifting apparatus, of the nature described, was now erected on the machine, so as to sift the pebbles rather severely, by taking out all the small and flakey specimens. This materially reduced the percentage of finished pebbles obtained from it; that, however, is not to be considered in comparison to the improvement produced in the powder.

I had all along been favourable to the principle of the other machine, proposed by Captain Smith, and had for some time, after a good deal of trouble and contrivance, got a design ready, by which the strips could be conveyed from the first to the second pair of rollers. When Colonel Younghusband found, therefore, that the percentage of pebbles produced with his machine was only about 60 per cent., I obtained his permission to have an experimental machine made according to my design. Fig. 8 on the following page will show its working :—

It will be observed that the difficulty consists in conveying the strips, which fall in regular succession, from the first to the second pair of rollers, so that they not only shall not inconvenience each other, but also shall change their direction from moving sideways to a motion endways. This I accomplished by allowing the strips to fall upon a board, over which a succession of strips of wood were moving sideways, and scraping along the surface. Each strip fell into a space between two strips of wood, and was carried sideways along the board. When the first strip got to the end of the board, it dropped over on to a band passing below in a direction at right angles, and was thus conveyed endways to the second pair of rollers. It is manifest, if the board remained stationary, the second strip would drop over on to the top of the first before it had time to clear out of the way. To prevent this the board was made to move backwards so that the second strip, instead of falling on to the top of the first, fell along side it, and slightly in

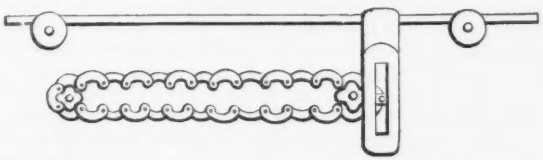
arrear, and so on with the next and the next, till the board had moved as far back as could be allowed. The direction of the board was then

FIG. 8. Scale $\frac{1}{10}$.



suddenly changed and it moved forward in the direction of the strips of wood and at the same rate, so as to form a false bottom to the compartments which contained the strips of powder. When the board had arrived again at the original position, it again suddenly changed its direction and the motion proceeded as before. The method of changing the direction of the board was by attaching it to an endless chain which passed over two small pullies. Thus the direction was reversed every time of passing over a pulley thus :—

FIG. 9. Scale $\frac{1}{3}$.

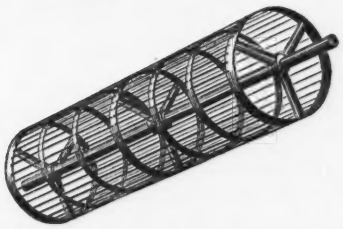


It will be observed in the last samples of firing given, that the density has increased. Of course it was at once apparent, if the fault of low velocity was due to the moisture, there was no need to attempt to meet the case by working to the low limits of density, and the density was therefore increased. It was found, too, that even 36 hours' drying at 125° F. was not sufficient, and on the 1st June the temperature of the stove was increased to 135° F., for 36 hours, with the following result. The moistures are given at the same time to serve as a guide, if possible, to what may be expected at proof :—

Stoving.	Density.	Moisture.	No. of Pebbles to 1 lb.	Experiment.		M. V.	Pressures.		
				Date.	No.		A.	B.	C.
4/6/72	1·781	—	—	12/6/72	1034	1450	16·4	16·8	16·0
1/7/72	1·780	—	—	12/7/72	1109	1465	18·2	18·9	17·9
6/8/72	1·784	·93	—	15/8/72	1200	1447	17·5	19·2	16·8
21/8/72	1·781	1·03	—	13/9/72	2	1493	20·8	19·8	18·0
2/9/72	1·779	·9	—	4/10/72	37	1494	19·7	18·7	17·1
3/9/72	—	—	—	4/10/72	39	1492	17·1	15·9	16·4
1/10/72	1·777	1·44	80	9/10/72	63	1491	18·3	17·4	17·1
4/11/72	1·782	1·38	80	8/11/72	110	1452	16·4	16·4	16·1
22/11/72	1·781	1·57	70	2/12/75	143	1494	18·5	18·8	18·0
4/12/72	1·779	1·34	72	13/12/72	170	1475	18·6	16·2	16·9
14/12/72	1·772	1·33	76	24/12/72	187	1541	19·7	19·1	19·4

I have brought down the manufacture to the end of 1872, and I think it will be admitted there is a considerable improvement on the state of matters which obtained a year before. Not only has the velocity been very much increased, but the pressures have been very considerably reduced. This latter point is mainly due to the increase in the size of the pebbles. Instead of being about 140 to a pound, they are now between 70 and 80, as shown by the column of figures. It will be observed that, with the introduction of a new proof gun, there is a considerable rise in the average velocity. This is, no doubt, due to the fact that the old gun had fallen off to some extent by the wear of the bore. It is not possible exactly to say how much, but evidently it is some 30 or 40 feet in 1,200 rounds. Stoving 3/9/72 is the first sample with the machine I have described as worked out by myself on Captain Smith's principle. It not only gave much better pebbles, but a much larger percentage—about 80 per cent. This machine has ever since continued in constant operation without mishap, and has done the greatest amount of the work of granulation or pebble-cutting. The sifting arrangement in use with Colonel Younghusband's machine was an ordinary shaking screen, but it was found that the mesh for taking out the small and flakey pebbles was apt to choke up and interfere with its proper action. One of the foremen of the Machinery Department suggested that a reel would be more suitable. This was applied to my machine with the oblong mesh described, and has been found to work very satisfactorily. A reel of the same sort is now being fitted to Colonel Younghusband's machine. The following figure will give an idea of this reel:—

FIG. 10. Scale $\frac{1}{30}$.



Before closing the work of 1872, I may give the following samples of the firing of mixtures of Waltham Abbey powder to show how satisfactorily the system of mixing has worked.

The hopper described was brought into operation in January, 1872, and the following are some of the mixtures made with it:—

Brand.	Stoving.	Density.	No. of barrels.	Experiment. Date.	Experiment. No.	M.V.	Pressures. A.	Pressures. B.	Pressures. C.
127...	23/1/72	1·760	51	—	755	1470	18·9	19·2	17·1
	19/2/72	1·753	127	—	738	1397	16·0	16·0	14·8
	26/2/72	1·749	62	—	774	1462	19·0	18·2	17·6
		Mean....	.....	.....	....	1432	17·4	17·3	16·0
No. 127.....	—	—	240	13/3/72	795	1432	17·4	16·7	15·6
136 ..	2/4/72	1·737	44	12/4/72	905	1461	21·1	20·5	18·5
	3/4/72	1·768	48	12/4/72	906	1396	17·5	17·9	16·2
	4/4/72	1·753	46	12/4/72	907	1432	17·2	16·8	15·8
	8/4/72	1·758	48	12/4/72	911	1452	20·1	19·4	18·9
		Mean....	.....	.....	....	1434	19·0	18·6	17·5
No. 137.....	.....	.....	186	19/4/72	916	1429	18·6	18·3	17·0
153...	10/4/72	1·736	45	19/4/72	913	1465	21·0	20·0	17·9
	29/4/72	1·751	47	10/5/72	929	1464	21·3	20·8	18·6
	15/5/72	1·782	47	23/5/72	976	1403	13·2	12·9	12·4
	16/5/72	1·785	48	23/5/72	977	1405	15·1	14·8	13·9
		Mean....	.....	.....	....	1434	17·6	17·1	15·7
No. 153	.....	.....	187	6/6/72	1018	1437	17·4	17·1	15·5
224...	29/8/72	1·764	43	13/9/72	11	1514	20·4	18·0	18·0
	31/10/72	1·774	47	8/11/72	108	1433	14·9	15·0	14·9
		Mean....	.....	.....	....	1471	17·5	16·4	16·3
No. 224.....	.....	.....	90	13/12/72	164	1472	17·1	16·6	16·9

Brand.	Stoving.	Density.	No. of barrels.	Experiment.		M.V.	Pressures.		
				Date.	No.		A.	B.	C.
225...	31/8/72	1·776	43	13/9/72	13	1539	22·0	20·9	20·0
	1/11/72	1·796	46	8/11/72	109	1416	13·6	13·8	14·2
		Mean....	.....	.....	....	1480	18·2	17·6	17·3
No. 225.....	.....	.....	89	13/12/72	165	1469	17·9	16·8	17·4

These are some of the results which are calculated to delight the heart of a powder-maker, and prove that a patient continuance in well doing is sure to be rewarded. We may take for granted that not only is the mechanical system of mixing in use at Waltham Abbey a perfect success, but that the method of testing the powder is not only consistent with itself, but calculated to produce one of the prime requisites of good powder, viz., uniformity of results.

A system of mixing powder similar to that just described, is in use at Wetteren, though at first it was not quite so perfect as the plan at Waltham Abbey. At Wetteren, the powder when finished is stored in large bins, and, when a batch of powder has to be made up for shipment, a small portion is taken from each bin for every barrel. Were the bins uniform, this system would be perfect. I believe, of late, attention has been given to insure uniformity of the powder in the bins, somewhat after the plan at Waltham Abbey. The following proofs are given of Wetteren powder:—

Lot.	Density.	Moisture.	Experiment.		M. V.	Pressures.		
			Date.	No.		A.	B.	C.
45	1·773	1·17	7/12/72	151	1427	17·5	15·8	15·1
46	1·766	1·17	„	152	1435	16·7	17·6	16·1
47	1·766	1·17	„	153	1452	17·2	17·0	16·4
48	1·771	1·17	„	154	1440	16·5	16·2	16·1
49	1·771	1·21	„	155	1416	15·6	15·6	15·2
50	1·775	1·13	„	156	1406	14·9	14·3	14·5
51	1·771	1·17	„	157	1438	16·2	17·5	15·3
52	1·773	1·20	„	158	1432	15·8	15·5	15·5

That to produce uniform powder is by no means an easy matter, the proof of the following lots of pebble supplied by Messrs. John Hall and Son will show:—

Lots.	Experiment.		M. V.	Pressures.		
	Date.	No.		A.	B.	C.
1388	7/3/72	785	1414	15·2	15·1	13·8
		787	1442	16·5	17·2	16·3
		790	1481	25·9	21·6	20·5
1399	13/3/72	802	1496	16·5	16·5	15·8
		803	1432	12·3	13·2	13·1
		808	1386	11·2	10·4	11·2

These samples are not given to show any inferiority of manufacture by Messrs. Hall and Son, but simply to illustrate the variations powder is capable of exhibiting, even when the manufacturers may be satisfied as to its uniformity. Messrs. Hall and Son were unfortunate in their first attempts to manufacture pebble, but they afterwards succeeded to a degree that has not left them inferior to any of the other manufacturers. The powder supplied by them, as a rule, exhibits low pressures in comparison with the velocities. Their powder is cut on the principle in use at Waltham Abbey, but the machinery is different. They pass the cakes through the same sort of cutting rollers or through a guillotine machine. In order to convey the cakes from the first to the second cutters, they press each cake between two sheets of canvas. These sheets of canvas hold the strips together after passing the first cutters. The whole cake is in this state turned by hand through a quarter circle and passed through the second pair. This plan is rather more troublesome and expensive than that at Waltham Abbey, but it is equally efficacious.

The Kames Gunpowder Company also at first experienced considerable difficulty in producing good pebble, as the following proofs will show :—

Dates of proof, 19th and 20th March, 1872.

Lot.	Samples.	Experiment.	M. V.	
71	1 and 2	846—7	1355	1372
72	1 and 2	848—9	1367	1369
73	1 and 2	850—1	1376	1360
76	1 and 2	844—5	1408	1394
77	1 and 2	853—4	1403	1389
78	1 and 2	855—6	1383	1395
79	1 and 2	857—8	1361	1373
80	1 and 2	859—60	1365	1378
81	1 and 2	861—2	1373	1372

The difficulty at Kames at this period was to get sufficient velocity, and it was not till after a visit had been paid to Waltham Abbey that they succeeded in mastering the difficulty. In their opinion the powder

they afterwards made, and which readily passed the specification, was inferior to that of which the proof has been given; by which I understand that it was not so thoroughly incorporated. I hope further on to give some experiments made at Waltham Abbey, which confirm this opinion.

Messrs. Curtis and Harvey supplied two sorts of powder, one, as I have stated, broken up by the ordinary granulating machine; the other consisting of pressed pellets, afterwards broken in two. The latter powder was found to give very good results when fired, as shown in the following proofs:—

Lot.	Experiment.		M. V.	Pressures.		
	Date.	No.		A.	B.	C.
1404	30/11/71	424	1450	15·4	16·4	15·7
		425	1440	16·1	15·7	14·0
		426	1438	13·3	14·3	14·1
1470	15/3/72	823	1422	18·1	17·3	17·2
		824	1424	17·2	17·6	16·7

None of the whole pellets, whether made by the trade or at Waltham Abbey, have ever succeeded in giving results at proof equal to those obtained with pebble, and it seems strange that the simple fact of splitting them in two should have such a beneficial effect. The reason is pretty well understood to be that pressed surfaces are not so readily or regularly inflammable as broken surfaces. The mere fact, therefore, of splitting the pellets furnishes two broken surfaces which the pellets would not otherwise possess.

The following proofs of Curtis's and Harvey's pebble show that though, as a rule, their powder is very uniform, they cannot always supply the same sort.

Lot.	Experiment.		M. V.
	Date.	No.	
1492	16/9/72	17 and 18	1452 and 1467
1493	„	19 and 20	1483 and 1498
1494	„	21 and 22	1502 and 1499
1495	9/10/72	55 and 56	1492 and 1495
1496	17/10/72	76 and 77	1415 and 1408
1497	„	78 and 79	1414 and 1407
1498	„	80 and 81	1466 and 1454

Messrs. Pigou and Wilks had considerable success in meeting the requirements of proof as regards velocity and pressure. The following samples of proof are given:—

Lot.	Density.	Experiment.		M. V.	Pressures.		
		Date.	No.		A.	B.	C.
876	1·758	3/1/72	525	1458	18·3	18·5	15·7
	1·776	„	526	1445	17·1	16·8	15·6
	1·789	„	527	1453	18·4	17·3	15·6
911	1·759	5/3/72	769	1463	19·4	19·6	17·7
	1·782	„	770	1425	14·4	14·4	14·4
	1·763	„	772	1431	17·2	16·4	16·2
934	1·788	12/6/72	1044	1435	16·8	17·0	15·6
	1·774	„	1045	1446	18·4	18·1	16·7

From what has been said, it will be seen that the manufacture and proof of pebble-powder had very greatly improved during 1872. Density, velocity, and size of grain had all increased, and pressure had materially diminished. The importance of velocity and low pressure need not be explained, but it may be stated that increase of density is an advantage, not only in improving the keeping qualities of the powder, but also in making it pack into smaller bulk, and that increase of size of grain appears to be the best known cause for facilitating the uniform ignition of the whole charge, and thus preventing those wave pressures which occur with smaller grain powder, and which are so very detrimental to the projectiles and powder chambers of the guns. Other things being equal, the larger the grains that can be used, the larger the charges which can be employed with advantage.

It will be noticed also that, instead of the year closing as did 1871, with low velocities, the difficulty is now to keep down the velocity. The beginning of 1873 shows no alteration in this respect, as the following new year's gift will prove:—

Stoving.	Density.	Moisture.	Pebbles to 1 lb.	Experiment.		M. V.	Pressures.		
				Date.	No.		A.	B.	C.
1/1/73	1·781	1·2	72	9/7/73	219	1530	22·4	22·4	21·3

Colonel Younghusband tried some experiments in order, if possible, to bring down the velocity, without leaving an undue amount of moisture in the powder. The first means of doing so that naturally occurs to a powder-maker is to dispense, to some extent, with the most important of all the operations, namely, milling. Four samples of shorter milled powder were accordingly made in different mills and under different circumstances.

They were made from the charcoal then in use, pressed as usual 15½

inches, and dried 36 hours at 135° Fah. The following is the result of proof:—

Stoving.	Density.	Moisture.	Pebbles to 1 lb.	Experiment.		M. V.	Pressures.		
				Date.	No.		A.	B.	C.
3/1/73 A.	1·771	1·08	70	9/1/73	221	1532	24·6	24·0	22·8
„ B.	1·761	1·05	70	„	222	1538	25·4	25·1	22·9
„ C.	1·768	1·01	76	„	223	1538	25·7	26·0	25·1
„ D.	1·759	1·05	66	„	224	1538	24·3	23·2	21·6

It will be observed that the density is low as compared with powder then manufactured, and also that the moisture shows the powder to be dry. The experiment was therefore repeated with powder pressed rather more—$15\frac{1}{4}$ inches—and dried 36 hours at 125° Fah.:—

Stoving.	Density.	Moisture.	Pebbles to 1 lb.	Experiment.		M. V.	Pressures.		
				Date.	No.		A.	B.	C.
25/1/73 A_1	1·782	1·08	72	3/2/73	267	1520	21·6	21·6	20·0
„ B_1	1·777	1·04	72	„	268	1535	21·8	21·6	20·2
„ C_1	1·789	·95	74	„	269	1535	23·3	22·4	21·1
„ D_1	1·786	·9	72	„	273	1541	22·1	22·3	20·4

There is some improvement in the pressures, but evidently not much, in the velocity. The experiment was again repeated with charcoal more highly charred, a well-recognised method of reducing the violence of gunpowder. The samples were pressed $15\frac{3}{8}$ inches, and stoved as in the last case:—

Stoving.	Density.	Moisture.	Pebbles to 1 lb.	Experiments.		M. V.	Pressures.		
				Date.	No.		A.	B.	C.
8/2/73 A_2	1·759	1·1	78	19/2/73	313	1539	25·5	24·5	22·4
„ B_2	1·759	1·08	76	„	314	1533	21·7	21·2	20·7
„ C_2	1·759	1·3	78	„	315	1507	19·7	18·5	18·1
„ D_2	1·759	·9	76	„	316	1541	24·4	23·3	22·6

Evidently there is no improvement yet, but four other samples were tried made with ordinary charcoal, pressed still more, $15\frac{1}{2}$ inches, and stoved only 24 hours at 125°, with the following results:—

Stoving.	Density.	Moisture.	Pebbles to 1 lb.	Experiment.		M. V.	Pressures.		
				Date.	No.		A.	B.	C.
6/3/73 A_3	1·795	1·26	80	14/3/73	413	1405	14·4	14·3	14·6
„ B_3	1·790	1·22	80	„	414	1408	14·2	14·8	12·7
„ C_3	1·790	1·30	70	„	415	1393	13·2	13·2	13·0
„ D_3	1·788	1·22	74	„	416	1383	11·7	11·6	12·0

I have given these samples at some length, because it was now that I fancied I saw into the secret recesses of pebble-powder and its mode of action. The whole question seems to me to lie in the porosity of the grains. The more porous the grains, the more violent will be the action. It is a case exactly similar to that of large interstices in large charges. If the grains be large it matters little if they be porous, for the pressure of the gas in the powder-chamber will force the flame into the very heart of the grains, and hence the very violent action of $2A_4$ powder. Now, it follows that anything which adds to, or takes from, the porosity of the grains during manufacture will have a corresponding effect at proof. It was to me a very remarkable fact that as summer advanced the tendency both with large and small-grain powders was for the density to increase. The presses had to be continually altered so as to press less and less in order to give the required density. No doubt this is due to the fact that the incorporating or milling is more perfect in summer than in winter, a fact well known to manufacturers.

The more milling the powder receives, the more pasty it becomes, so much so that with fine-grain powder, where long milling is used, the powder on the beds of the mills has a tendency to adhere to the runners. This pastiness has the effect of rendering the powder more compact and easily pressed. The opposite effect, of course, takes place with shorter milled powder. It will not press so close together, and will be less dense and more porous than powder longer milled. This accounts for the low densities of the 3/1/73 samples. It also accounts for their more than usual dryness, for, if the powder be porous, the more readily will it part with its moisture.

The same remark applies to 25/1/73 samples, for evidently both sets have been dried sufficiently, and part of the moisture is to be regarded as what the powder has re-absorbed after stoving. The 3/1/73 samples being less dense, though they have been more dried at first, may, at the time of being tested for moisture, have absorbed more moisture than the 25/1/73 samples which are denser. The amount of moisture, however, in powder gives very little idea of what may be expected at proof. This I had long known, and a very short inspection of the samples already given, will show that this is the case. The reason of this, however, was now plain to me; for evidently the powder must dry from the surface to the centre, and probably in the centre of each grain there is a considerable portion which receives little drying. The

average amount of moisture will therefore be determined by the amount of moisture which was in the powder before stoving, and will give but little idea of the amount of dryness of the outer portions of the pebbles, which have the most important effects on the proof.

The 8/2/73 samples admit of ready explanation on the same principles. Though more pressed, the density is again lower. The grains of charcoal, being harder, will still more refuse to incorporate, and will make the powder more brittle and less pasty, which will manifest itself in the density at pressing.

The 6/3/73 samples show the old tendency to low velocities. Comparing, however, these samples with powder made at the same period in 1871 and 1872, which was dried the same amount, it appears that the densities then were less, and consequently the rule still holds good.

With fine-grain powder, long milling and slack-burned charcoal increase the velocity obtained at proof, but with pebble the reverse holds good, and here we have an exact parallel to the case of fine-grain and large-grain powder in large charges. With fine-grain powder in small charges, the charcoal probably has not time to seek its oxygen unless it be brought very intimately in contact with it; but in large charges, where the time of explosion is necessarily much longer, owing to the great resistance of the shot, time is not so great an object, and the great heat may release the oxygen much more effectually and rapidly. It is probable also that each small particle of charcoal may require a certain time to burn, and there may be ample time in large charges, but not in small charges, unless the particles are pulverised considerably by long milling. It is well known that a "mixed charge" will only just flare up if fired in a small quantity, but if it be fired in bulk the result is an explosion. This explains the observation I made with regard to the Kames pebble, for, if that firm overmilled their powder with the idea of getting up the velocity, from the observations I have made, it will be seen that it would produce the opposite effect.

Another observation may be made with regard to the manufacture of pebble-powder bearing on the same point. Powder when incorporated in the mills usually has a certain percentage of moisture in the charge with a view of aiding the incorporation. Fine-grain powder is usually worked with about 3 per cent. of moisture, but pebble with from $3\frac{1}{2}$ to 6 per cent. An explosion of fine-grain powder with 3 per cent. of moisture is very violent, and generally destroys the building; but, with pebble-powder and 5 or 6 per cent. of moisture, the explosion does little or no damage. It is, therefore, a great advantage to work with as much moisture as possible. Some have thought that the more moisture in the powder when milled and pressed, the more moderate will be the results of proof, and that this is due to a sort of hard and crystalline texture which the powder thus assumes. I do not believe in this theory, and certainly the results of proof do not bear it out. It is true no doubt that powder if too dry will not pack well together, even if pressed with a very high pressure, and this was found to be the case in the earlier experiments to obtain powder for heavy guns,

when the Doremus pellets, which were pressed with as much as three tons to the inch, were found to be very violent even in field guns. A certain amount of moisture must therefore be in the powder when milled and pressed, in order to make it pack together; but if this amount is exceeded, the results are prejudicial, and, with pebble-powder, instead of mitigating the violence, rather increase it. No doubt, if the powder be not properly dried, the moisture has a moderating tendency, and I think this is the reason which has given rise to the crystalline theory. If, however, the powder be thoroughly dried, it has always been found that with moisture over a certain percentage—about $4\frac{1}{2}$ or 5 per cent.—it is much more difficult to get a high density. I think this and the more violent action at proof are caused by the moisture in forcing its way from the interior of the pebbles, forming porous channels, which not only swell the powder, but also leave passages for the flame to penetrate more readily into the interior. If too much moisture be in the powder when pressed, the water can be seen to be squeezed out, showing that the extra amount can produce no good effects, and must, if confined, prevent a high density being obtained.

The great difficulty of getting the moisture from the interior of the pebbles, as has been stated, is another reason why too much moisture should not be used. In making these observations, however, I should observe that they are entirely my own views, and are not necessarily accepted by everyone.

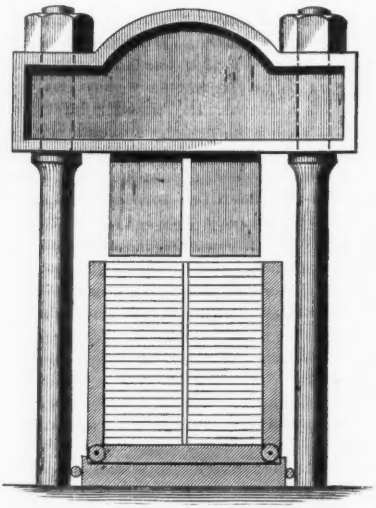
I may however make a remark to which all I have said seems naturally to tend, namely, that to produce a powder, which shall be moderate in its action, is both troublesome and expensive, unless an undue amount of moisture be admitted, but a powder can be produced, safely, expeditiously, and economically, which, though somewhat violent in its action, does not give an exceptionally high pressure in comparison with the velocity. If the guns will stand, no difficulty will be found in providing a powder capable of giving the very best results.

The manufacture of pebble has been carried on in 1873 much in the same manner. The variations of the seasons have to be studied, and, as a rule, it has been found that density is more easily obtained in summer than in winter, owing to the more effectual incorporation. The amount of milling has been reduced, as it appears unnecessary to prolong this operation, which is the most dangerous of all, more than is absolutely necessary.

The press-boxes at Waltham Abbey produce cakes of powder 30 inches square, which are not only too large to pass through the pebble machine, but the size of the copper plates between the cakes allows the plates to buckle and so produces cakes of uneven thickness. The perfect action of the machine depends to a great extent on the uniform thickness of the cakes, otherwise the long strips are broken up into short pieces. A plan of remedying this defect suggested by the Assistant Chief Foreman of machinery was carried out during 1873. It consists in dividing the press-box and block into two, so that the cakes produced are only of half the width and suitable at once to pass through the pebble machine without being broken up.

The following figure shows the method adopted:—

FIG. 11. Scale $\frac{1}{10}$.



Care, however, must be taken after the cakes are pressed to keep them from buckling, which they will readily do when first pressed.

A large amount of L. G. powder has been re-worked during the year. The following are the first proofs of this powder which was made from Curtis's and Harvey's L. G. powder. The drying was 38 hours at 127° Fah.

Stoving.	Density.	Moisture.	Pebbles to 1 lb.	Experiment.		M. V.	Pressures.		
				Date.	No.		A.	B.	C.
14/7/73	1·806	1·27	74	29/7/73	682	1415	13·5	13·2	13·8
15/7/73	1·803	1·48	74	„	683	1409	13·2	12·9	13·0
17/7/73	1·803	1·28	76	„	684	1356	11·6	11·2	10·3
18/7/73	1·804	1·41	—	„	685	1419	13·2	13·2	13·3

These stovings were mixed and re-dried and again proved.

Experiment.		M. V.	Pressures.		
Date.	No.		A.	B.	C.
15/8/73	697	1454	14·4	14·7	14·2

This is most excellent powder, and it will be observed that the density is high and the powder consequently difficult to dry.

The following are proofs of pebble re-worked from Hall and Son's L. G.:—

Stoving.	Density.	Moisture.	No. of pebbles.	Experiment.		M. V.	Pressures.		
				Date.	No.		A.	B.	C.
28/11/73	1·789	1·20	76	8/12/73	785	1432	14·8	15·0	14·6
1/12/73	1·797	1·11	76						
9/12/73	1·792	1·37	76	15/12/73	790	1454	15·9	15·6	15·1
10/12/73	1·796	1·07	82						

These stovings were dried 36 hours at 127°.

At this time, and for some months previously, it has been the *rule* to prove double stovings instead of proving each separately, and this is attended with no inconvenience; for, even if a double stoving fails, there is still opportunity in the four-way hopper of mixing it with another double stoving of an opposite character.

It will be seen that the question of stoving is a very important one. What is required is to give the powder that amount of stoving which will leave it in a normal condition as regards moisture, so that afterwards the velocity shall not be affected. In order to obtain some data on this point, 10 barrels were dried 72 hours at 125° Fah. and fired once a month.

Stoving.	Density.	Moisture.	Experiment.		M. V.	Pressures.			Corrected M. V.	Corrected Pressures.		
			Date.	No.		A.	B.	C.		A.	B.	C.
31/5/72	1·773	77	12/6/72	1038	1502	20·4	19·8	18·8	—	—	—	—
,,	,,	—	12/7/72	1107	1490	19·3	19·5	18·6	—	—	—	—
,,	,,	—	7/8/72	1157	1473	19·3	18·4	16·5	—	—	—	—
,,	,,	—	13/9/72	7	1515	22·6	22·4	19·4	—	—	—	—
,,	,,	—	9/10/72	57	1520	20·4	19·0	18·9	1523	20·4	19·0	18·9
,,	,,	1·28	18/11/72	121	1501	18·2	18·2	17·1	1507	18·3	18·3	17·2
,,	,,	1·17	13/12/72	166	1499	19·4	19·2	17·4	1507	19·5	19·3	17·5
,,	,,	1·33	9/1/73	225	1511	19·5	20·0	19·3	1522	19·7	20·2	19·5
,,	,,	1·38	10/2/73	297	1486	17·9	17·5	17·8	1501	18·2	17·8	18·1
,,	,,	1·35	12/3/73	398	1486	19·3	18·3	17·4	1506	19·7	18·7	17·8
,,	,,	1·30	10/4/73	501	1474	16·8	16·6	16·5	1499	17·3	17·1	17·0
,,	,,	1·16	14/5/73	544	1495	18·3	18·9	17·8	1522	18·8	19·4	18·3
,,	,,	1·3	19/6/73	603	1493	19·8	19·7	18·2	1523	20·4	20·3	18·8
,,	,,	·95	15/7/73	657	1485	18·9	18·5	17·5	1518	19·5	19·1	18·1
,,	,,	1·11	15/8/73	698	1485	21·1	20·5	18·6	1520	21·8	21·2	19·3
,,	,,	1·21	19/9/73	732	1458	18·5	17·9	17·0	1495	19·2	18·6	17·7
,,	,,	1·44	17/10/73	746	1476	17·5	17·9	17·0	1513	18·2	18·6	17·7
,,	,,	1·41	14/11/73	769	1452	16·6	16 3	15·4	1490	17·3	17·0	16·1
,,	,,	1·34	15/12/73	788	1470	17·8	17·2	15·9	1509	18·6	18·0	16·7
,,	,,	1·18	12/1/74	801	1483	18·1	17·9	16·3	1523	18·9	18·7	17·1
,,	,,	1·20	13/2/74	106	1507	18·1	18·9	18·3	1512	18·2	19·0	18·4
,,	,,	1·15	20/3/74	847	1426	15·3	14·7	15·1	1468	16·1	15·5	15·9
,,	,,	1.0	20/4/74	875	1456	18·0	17·1	17·0	1500	18·8	17·9	17·8
,,	,,	—	21/5/74	144	1495	20·3	19·5	19·3	1502	20·4	19·6	19·4

It will be observed in the additional columns for velocities and pressures, that corrections have been made for the wear of the bore of the proof gun. These were obtained by firing identical samples from two proof guns, one new and the other worn.

Stovings.	Density.	Moisture.	Pebbles to 1 lb.	Experiment. Date.	Experiment. No.	M. V.	Pressures. A.	Pressures. B.	Pressures. C.
9/8/73	1·777	·94	80	21/8/73	706	1498	20·3	20·3	17·7
					4	1537	20·6	20·3	18·7
11/8/73	1·787	·99	70	,,	707	1467	18·1	17·8	17·5
					5	1508	19·1	18·4	17·5
12/8/73	1·787	1·14	74	,,	708	1459	16·5	16·5	16·1
					6	1486	17·0	16·9	16·7
21/8/73	1·799	99	64	3/9/73	726	1433	16·0	15·7	14·6
					16	1470	17·6	16·6	16·4
27/8/73	1·785	1·11	64	,,	727	1441	14·9	14·8	15·7
					17	1478	16·5	16·5	16·5
23 25 8/73	1·793	1·04	66	,,	725	1434	15·1	14·4	13·6
					15	1470	15·8	16·1	15·0
24 25 2/74	1·808	1·41	77	9/3/74	825	1419	16·4	16·1	15·5
					110	1450	16·8	15·9	16·5
25 27 2/74	1·804	1·37	78	,,	826	1399	17·4	16·5	14·8
					111	1439	16·6	16·3	15·2
26 27 2/74	1·779	1·05	77	,,	827	1484	22·3	22·1	20·2
					112	1535	22·8	23·1	21·9

From these experiments it is concluded that about 5 feet must be added for 100 rounds to reduce the velocity to that of a new gun, and about 2 cwts. for each 100 rounds for pressure. The corrections are not shown in the old gun in use in 1872, as that gun as a rule fired much less violent powder, and the corrections would probably be $\frac{1}{8}$ less. If we neglect the sample fired 13/9/72, where the pressures are evidently exceptionally high, it will be observed that the powder at first loses in velocity and pressure from its having been overdried, but that afterwards it does not materially lose its velocity or pressure when it once has reached a normal state of moisture, as it may be supposed to have done in November, 1872.

Some experiments have lately been made by Colonel Younghusband as to the time required to dry powder of large size of grain. The samples chosen were inch cubes, and the specimens were dried whole and compared with similar specimens broken up to a size rather larger than R. L. G. with the following result:—

No. of hours dried at 160° Fah.	Loss of moisture in inch cubes.						
	Waltham Abbey.		Hall and Son.				
	Density 1·792.		Density 1·82.				Density 1·75.
			A		B		C
	Whole.	Broken up.	Whole.	Broken up.	Whole.	Broken up.	Whole.
24	·284	1·103	·237	1·062	·290	1·312	·308
48	·464	1·103	·402	1·194	·501	1·527	·484
72	·490	1·103	·568	1·261	·712	1·527	·625
96	·594	1·103	·663	1·261	·817	1·527	·659
120	·619	1·103	·710	1·261	·897	1·527	·659
144	·645	1·103	·805	1·261	·976	1·527	·681
168	·697	1·103	·876	1·261	1·108	1·527	·703
192	·800	1·103	·947	1·261	1·134	1·527	·703
216	·800	1·103	·971	1·261	1·213	1·527	·703

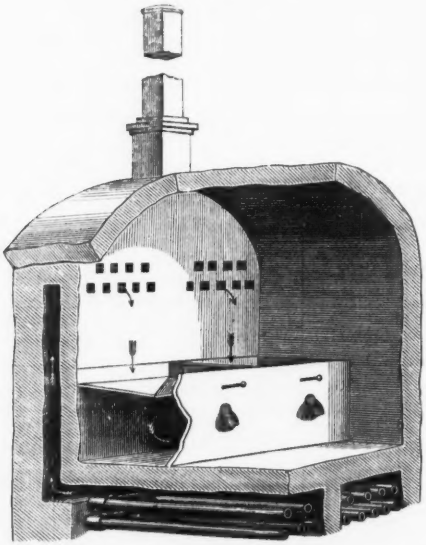
The question of the best method of drying powder has received some attention of late at Waltham Abbey, and, in order to gain some information to aid in the construction of a new stove, an experimental stove was built of 8 feet square internal floor and about 10 feet high. Colonel Younghusband wished to have the hot air pass from above downwards, as that is evidently the best method of drying, and is used in some places where drying is carried on, as at Enfield Lock, for drying wooden stocks. In the stoves in ordinary use at Waltham Abbey it is found that the powder sweats very much during the first 10 or 12 hours, and evidently that there is not sufficient circulation to carry off the moisture. The hot moist air seems at first to rise and get heavy

with moisture and then come down again to the bottom of the stove, circulating only in the stove itself.

But if the hot air come in at the top and descend it has no tendency to rise again as it absorbs moisture, cools, and becomes heavy. Evidently also pebble-powder gives special facilities for drying, as the large interstices give facilities for making the current of heated air pass through the powder.

The plan adopted therefore was to make the current pass down through a thick layer of the powder, which for this purpose was placed in bins. No other passage was allowed for the air. An idea of this stove will be obtained from the following figure:—

FIG. 12. Scale $\frac{1}{20}$.



It will be observed that the pipes have been placed underneath the stove. The object of this is to insure circulation. Hot air tends always to rise as water tends to fall. But as water will always when confined in any case rise to its original level, so I conceived hot air, when confined to a passage, will always force its way down to its own level. If an outlet therefore be allowed for the hot air from the bottom of the stove a continual current ought to be established. The outlet, however, was led into a flue so as further to increase the draught.

For some reason or other a sufficient current was not established until the flue was increased by a wooden continuation, but when this was added it was found, when at work, that the draught was sufficient to draw so great a quantity of air through the stove as to bring

down the temperature. The temperature could be raised by the diminishing the opening by which the external air was admitted to the steam pipes to become heated. The best plan would be to bring the outlet into communication with some arrangement which would produce a partial vacuum, such as a steam jet; for a vacuum is a well-known method of drying. Thus the temperature might be lowered in the stove with advantage to the drying of the powder, a low temperature and sufficient current of air being the best plan of drying.

I may conclude this paper by giving a few samples of powder fired in the 35-ton gun, by way of experiment, to see what powder is likely to be most suitable. All the rounds were fired with 110 lbs. of powder and 700 lbs. projectile.

Description of powder.	Density.	Fired in 35-ton gun.			Fired in 8-inch gun.				
		Muzzle velocity.	Pressures.		No. of round.	Muzzle velocity.	Pressures.		
			A.	C.			A.	B.	C.
W.A. pebble, 22/4/73	1·79	1345	23·2	16·6	556	1468	17·9	17·1	16·7
„ inch cubes, 23/4/73	1·79	1328	21·8	19·2	564	1431	18·2	17·3	16·4
„ lot, 1970	1·78	1359	23·4	20·7	618	1486	19·5	19·7	18·5
„ inch cubes	1·82	926	2·5	broke	800	750	—	—	—
„ „ „	1·77	not fired			94	1535	21·7	20·5	18·8
„ „ „	1·75	1352	24·1	19·6	104	1485	17·0	17·3	15·7
„ „ „	1·73	1368	24·8	22·3	105	1504	18·4	18·8	18·1
„ 1¼-inch cubes	1·77	1334	20·7	18·5	95	1469	15·7	15·0	15·5
„ „ „	1·75	1311	24·1	16·0	96	1425	13·2	13·2	12·6
„ „ „	1·73	1334	22·5	19·4	98	1456	14·6	14·7	14·2
„ 2-inch cubes	1·79	1095	7·5	6·8	—	—	—	—	—
„ „ „	1·77	1262	18·0	15·1	99	1429	13·5	13·9	—
„ „ „	1·75	1239	13·4	11·3	100	1367	9·9	9·9	10·2
„ „ „	1·73	1241	13·6	11·7	101	1371	10·8	10·6	10·8
H. and S. inch cubes, A.	1·82	1355	19·8	18·2	736	1440	12·8	12·9	13·3
„ „ B.	1·82	1376	24·0	22·4	738	1480	11·3	11·7	11·5
„ „ C.	1·75	1385	23·8	19·8	1192	1483	17·7	18·6	18·2

These are some very remarkable results, which doubtless are all capable of explanation, but require a more accurate knowledge of the whole curves of pressure for their complete elucidation than the mere maximum pressures are capable of furnishing. For the present, however, they must be left in the hands of the Committee on Explosives, with the remark that, true to themselves in their apparent inconsistencies, these samples in many cases seem to arrange themselves in exactly the opposite order to what might have been expected. One observation, however, I may make, the truth or error of which time and further experience may possibly determine. The effect of size of grain is well known, and the theory of each grain burning from surface to centre has often been advanced, and therefore calls for no

special remark. It should, however, also be understood that with this theory must be combined a consideration not only of the density but also of the varying porosity of powder, which allows each grain to burn more or less rapidly according as the density is less or more, and more or less unevenly according to the number and size of the pores.

Porosity and density, though intimately allied, are not necessarily identical, and this helps to a great extent to explain some of the apparent anomalies.

Powder of a density greater than 1·82 or 1·84 *does* burn uniformly; and Captain Castan* says that such powder when picked up unconsumed, after having been fired from guns, shows none of the pit marks which are to be found with powders of less density. These pit marks are doubtless due to the penetration of the flame into the porous channels in the grains, which allow the flame to enter further into the interior than would otherwise be the case, and thus accelerate the combustion. The effect of porosity, however, is mitigated by the amount of moisture the powder may contain, and which, for some cause or other, seems to have an effect on the rapidity of combustion much greater than would be anticipated. Possibly it may generate steam of a tension sufficient to counteract the pressure of the flame. It is not, however, the actual amount of the moisture that affects the rate of combustion so much as the position it occupies. Moisture in the interior of a grain affects the combustion but slightly, but moisture in the exterior moderates considerably the rate of combustion at the period when the effects of greatest importance are produced.

Waltham Abbey inch cubes of high density were thoroughly dried, and the mild character of the sample, 1·82, is to be regarded as entirely due to the high density. It is not to be compared with Messrs. Hall and Son's sample of the same density, which was made with a different charcoal, viz., dogwood, instead of alder. Some of the discrepancies obtained with the other samples, however, are not so easily explained, but it is probable that the reason why in some cases the lower densities gave more moderate results than the higher may be that the lower densities may have allowed the moisture to penetrate by absorption further into the pebbles, and that each grain was somewhat in a condition which may be represented in the following figure, where the shaded portions represent the moisture:—

FIG. 13. Scale ½.

* Avec les poudres qui dépassent 1·800 de densité, la forme semblable à celle du grain primitif est encore mieux conservée, et la profondeur des alvéoles, diminuant très-notablement, devient à peu près nulle quand on opère sur des densités de 1·840 ou plus.—*Etude des poudres pour le nouveau matériel de l'artillerie de terre, par* F. CASTAN, *Capitaine d'Artillerie à la Poudrerie du Bouchet.* 1873.

Correct inferences cannot be drawn till the whole grain has reached its normal state of moisture, and only thus can the relative effects of size of grain and density be fully determined. This manifestly must be a work of considerable time. It is worthy of remark, however, that lot 1970, which is a violent service pebble set apart for the proof of guns, does not appear to be much behind even the very best of the samples, if we have regard to a comparison of velocity and pressure. An increase of the size of the charge with some of the more moderate specimens, may, however, determine in favour of some of the milder powders for our heaviest guns.

Commander W. DAWSON, R.N.: I paused before rising, in the hope that some powder manufacturer would get up to discuss the question of improvements in powder manufacture; but, as a gunner, I may approach the question from the side of the guns. Before doing so, however, I must compliment the Institution on having obtained such an able paper as we have heard this evening from Major Morgan; I compliment, also, the authorities on their farsightedness in placing before us so much minute information of a highly scientific character, upon questions which are of rising importance, not only to us professionally, but to the country at large. It is remarkable that this discovery that density is not a sufficient designation for gunpowder without a knowledge how that density is produced—whether by much pressure and little moisture, or the reverse—and the effect of the presence of moisture upon the powder-pressure and velocities of the shot should have struck two large minds at the same time. But it appears that while Major Morgan and his associates were working out this problem in England, an Indian Committee, under an Officer of very great scientific repute, Colonel Smythe, of the Royal Artillery, had been working out the same idea, and arriving at very much the same conclusions, from the result of experiments in that country—experiments necessarily not so complete as those that, with better apparatus, we have been able to carry out at home. But it is important to have it on record that the Indian Government, led by the Special Committee, superintended by Colonel Smythe, had already arrived at the conclusion that moisture was a disturbing element, at the same time that we in this country were arriving at it by independent investigations. The problem which I take it we, as gunners, want to have solved, is to be enabled to burn with uniformity the largest charge of powder in a given gun with the least pressure and the greatest velocity. The difficulty in the way of increasing the charge of powder is the irregular action which takes place whatever kind of powder be employed, when the charge is unduly increased. If we can control this irregular action of the heavier charges in any degree, we are able to increase to that extent the amount of powder made use of in a given bore, and to that extent to increase the efficiency of the gun. It is, therefore, a very important question to know how to extend our control over this irregular action, and the powder manufacturers are doing a great deal to improve the power of our guns by every step towards further control, which helps the gunner to increase the charges by the alterations in the size, shape, density, and hardness of the grains. But when we look at the specimens before us, and see the variety of shapes and sizes of the grains, and then look on the table before us at the varieties and uncertainties of densities, we see that the problem of uniformity of combustion and extension of the limits of control is as yet unsolved; that there remains much more for discovery by future experiment; and if I venture, as an artillerist, to rise, it is in the hope of throwing my humble mite of light upon the direction which future experiments may take. Looking at it simply from the gunner's point of view, I would call attention to those means that are within the gunner's reach for controlling the irregular action of powder when it passes from the manufacturer's into the gunner's hands. I need not say that we cannot have powders of different granulation for every variety of gun in the service, nor that if we had a powder of a particular grain and density specially adapted to each nature of gun, we should always be sure to have the right powder brought up to the right gun. But it is very important that, if we have a powder of given grain, density, and moisture supplied

to the Service, we should be able to alter the treatment of that powder in the cartridges, so as to enable us to use powder of the same granulation, &c., in a variety of different guns, controlling its action differently according to the requirements of the different sized bores. Now, the mechanical condition of the cartridge has a very material effect upon the pressure in the bore, and thus upon the uniformity of action when using the heavier charges. It is familiar to every one who has practised with Mr. Henri's rifles, that if you simply tap the cartridge sharply on the base so as to shake the powder well down, you will insure a good kick on the shoulder, showing that you have increased the powder-pressure by the compression of the grains without at all altering the description of powder used. That suggests the idea that if, when the powder is loose, there is a different amount of pressure than when it is packed by being shaken together, there will be also a reduction of pressure if an air-space be introduced into the interior of the cartridge. There have been some very important experiments made by the Special Committee on the explosive force of L.G. powder in India, in order to test the amount of air-space which will produce the greatest velocity from a given charge of powder in a given bore with the least variations of recoil or violent pressure. Paper cylinders of various lengths were embedded in the cartridges, the best results being achieved in an 8-inch bore with 16-lb. charges, when two inches of powder surrounded the hollow paper cylinder on all sides and at both ends. They arrived at certain conclusions which have a very important bearing upon the weight of battering charges, because they showed the possibility of controlling the irregular action with much larger charges than are at present in use, by a simple introduction of an air-space of an ascertained size and form in the centre of the cartridge. The report of that Committee, which I hold in my hand, contains some very important facts in connection with this. It is found that, by the introduction of air-spaces either in the centre or around the cartridge, the pressure is reduced one-half in an 8-inch gun, whilst the same velocity is attained. This is a very important fact to be looked into, and to be worked out for each calibre. Still more interesting and important results followed from the simple use of paper partitions in the cartridge as barriers to the too rapid transmission of the igniting flame. By introducing two longitudinal, equidistant, and parallel barriers into the cartridge, and two discs of pasteboard at equal distances, thus dividing the cartridge into thirds lengthways and longitudinally, the progress of combustion was delayed. That had a great effect in reducing the pressure when heavy charges were fired, enabling a larger charge to be used with the same amount of pressure, and therefore ensuring a higher velocity and greater striking force.

That also reminds me of a suggestion made some years ago by my friend, Captain O'Hea, that reduced pressure and increased velocity might be arrived at by a proper arrangement of powder of different densities and different grains in the same cartridges, separating them by cakes of powder (but, as I would venture to suggest, after reading the report of the Indian Special Committee, separating them by thin pasteboard); by that means he hoped to improve the control, and, I think, might obtain higher velocities with less pressure upon the gun. But the elements of uniformity of powder-pressure are largely affected, not only by the mechanical conditions of the cartridge, but by the mechanical conditions of the shot. It is familiar to us all that a round shot, with a considerable amount of windage, rebounds in the bore; each rebound amounting to an obstruction to the exit of the shot, and it depends very much in what part of the bore that obstruction takes place, and the force with which the rebound takes place, as to the power of the obstruction, and consequently the variations of pressures to be expected. If we could imagine a round shot going out of a gun without any rebound whatever, then we should be able to use a much larger charge with a much lower degree of pressure and with enhanced velocity. The same observation may be made when elongated shot are made use of. I understand that the tables before us have been drawn up from experiments made with unrifled elongated shot, placed in a smooth-bore gun, resting upon the bottom of the bore without any rifling agencies. Under those circumstances, I need hardly remind you that the influence of gravitation acts upon the shot within the barrel in the same way as if it was outside the gun, and that it necessarily lies on the bottom of the bore where the friction and weight are alone felt. If the bottom be clotted with fouling matter from previous discharges, or even if the

barrel be cleaned out, the ordinary roughnesses of the bore and of the exterior of the unstudded shot, set up a certain friction between them which amounts to an obstruction such as is not to be found above the seat; moreover, in consequence of the windage between the top of the bore and the top of the shot, a cross action is set up and a rebound takes place. The same thing occurs, as Major Morgan has already pointed out to us on a former occasion in a paper read in this Institution, when the shot is raised off the bottom of the bore by setting it upon two studs and balancing it in unstable equilibrium. But if, instead of balancing the shot upon two studs, four studs be employed, the additional ones being at the extreme end of the base, and at the extremity of the shoulder, the shot would be fairly raised, so that nothing but the studs would touch the bottom of the bore. There would still be a certain amount of friction on the studs at the bottom, and space for windage at the top, so that there would still be a liability to obstruction, but not with the same uncertainty or to the same extent, because the shot would be more fully supported and more nearly centred in the bore. The more nearly the axis of the shot coincides with the axis of the gun, the more uniform will be the obstruction to the exit of the projectile. That is not done when proving gunpowder, nor, I believe, is it done in any case; but I am told that in the 35-ton gun, a third stud has lately been added to the shot, so that the projectile is not so nearly balanced in unstable equilibrium as it was. If those studs be placed well apart, I hope that, perhaps, a trifling more uniformity, with greater velocity, may result, and possibly a heavier charge may be used in that gun now than before. In looking over the report of the Indian Special Committee, I have been interested to see a confirmation of this view, which I ventured to put before this Institution a year ago, in a paper* in which I pointed out that there were irregularities in the powder-pressure registered in the 35-ton gun that were not to be accounted for by any errors in the manufacture of the powder, or by anything that can be fairly traced to the manufacturer's ignorance of his art. For example, I pointed out that a given charge of powder fired in the 12-inch bore with a similar 700-lb. shot, produced three times the pressure on one occasion that it did on another, that is to say, it produced twenty tons on one occasion, and sixty tons on another. That could not possibly be traced to any of these manufacturing difficulties, to extra moisture in the powder, &c., because the powder was taken from the same lot, and was, in all other respects, identical; and I endeavoured to trace that not unusual irregularity up to the uncertain action of the balanced shot in offering different degrees of obstruction to the escape of the gases. Some experiments were made by the Indian Committee, of which Colonel Smythe was the President, a couple of years ago, in which certain rifled bronze guns were tried—two of which burst violently, and the third was rendered unserviceable after a small number of rounds with service charges and balanced shot. The question arose, what part of these guns gave way? It was not the powder-chamber where the greatest pressure should be exerted by the powder, but the guns gave way in that part of the bore which is traversed by the shot. Attention was apparently drawn to the subject, and in Colonel Smythe's report, on the 9th of August, 1872, to the Deputy-Adjutant-General of the Royal Artillery in India, were these words, which bear directly upon comparative powder-pressures. He says:—

"I have the honour to bring to your notice some particulars in the action of muzzle-
" loading rifled guns, which I consider to be intimately connected with the most urgent
" of the difficulties at present met with in the system, and which would appear to
" have received peculiar illustration in the recent experimental practice with bronze
" guns. . . . .

" In the experimental practice referred to, the sole gun which survived, being
" apparently of more plastic material than the other two, exhibited, by means of the
" gutta-percha moulds taken of parts of its interior after 316 rounds, a curved inden-
" tation or beating down of the driving faces of the grooves which was most marked
" just *in front of the position of the studs of the projectile when in its seat*, but which
" recurred at successively increasing distances along the bore with decreasing dis-
" tinctness. The first occurring defacement was so considerable as to leave no

* Powder-pressures in the first 35-ton gun. By Commander W. Dawson, R.N. See Journal, No. 70, vol. xvii, page 1, *et seq.*

" certain remnant of the original driving surface, which, however, reappeared unin-
" jured immediately beyond, to be again abated and again restored more gradually
" further on.

" The other two guns burst after 109 and 216 rounds respectively, each testifying
" to the region of *greatest disruptive energy being coincident with the position of the*
" *first and most violent indentation in the surviving gun.* These results appear to
" signify that the shot (as might, indeed, have been forecast for it on mechanical
" consideration) having, on first starting, a certain, however minute, space in which
" to travel freely forward and acquired direct speed before receiving any control
" from the inclined driving faces of the grooving, meets the latter with a violent
" blow, and is thrown off from them with the corresponding reaction. Its next
" course is less clearly indicated, probably the studs come into collision with the
" opposite or loading faces of the grooves, but they would necessarily leave but little
" sign of it there; at any rate, the shot, having left the driving faces abruptly, comes
" back to them again and again, each time with less violence and more nearly regu-
" lated into the fitting spin."

The mechanical action thus found by the President of the Special Committee written on the interiors of the three Indian bronze M.L.R. guns, agrees in the main with the mechanical writings found in the steel bore of the late 35-ton gun intended for the "Devastation," the "furrs," "cracks," "enlargements," &c., which terminated the brief life of that gun, all occurring just in front of the seat of the studs, and justifies the Admiralty in their chary use of battering charges and shot from the "Devastation's" guns, and their not allowing as many as a dozen such rounds to be fired from any one 35-ton gun in the same day. Colonel Smythe proceeds to explain the bearing of this mechanical action upon the irregularity of the higher powder-pressures. He says:—

" It is to the earlier and less uncertain part of the action that I think consideration
" urgently due. Most explosive agents, however manageable under simple con-
" ditions, if *interrupted in their plain course by sudden check or cross action,* receive,
" as it were, by inversion on themselves, a kind of multiplication of energy which
" renders their violence extraordinary. Some recent demolitions by gun-cotton have
" given striking illustrations of this kind of development of latent force; various
" gunpowders are credited with more or less of this property, and it appears to me
" that *the compound violence developed in the powder gas by the backward shock first*
" *transmitted to it by the shot when, travelling at speed, its studs strike the inclined*
" *faces of the grooves,* goes far to explain, not only the bursting of those two bronze
" guns, but also those apparently anomalous local pressures which have caused so
" much anxiety recently in the testing of the largest and most powerful of the
" M.L.R. guns in England."

Suspicion having attached to the gunpowder which destroyed these three bronze "Woolwich" rifled guns, samples were sent home to the English Explosives Committee, who tested them, and reported, 8th of May, 1873, "that none of the " Ishapore powders are of a violent nature. . . . . The particular brand from " which the charges which burst the bronze guns were taken, appears to be of a mild " nature, and not calculated to exert any abnormally destructive power, whether " employed in large or small calibres." This would seem to point to the balanced shot as the destructive agent.

After questioning the value of the smooth-bore experiments made in England to test the relative pressures developed in smooth-bore and in M.L.R. guns, the President of the Indian Special Committee proceeds:—

" The second result of the peculiar action, as affecting the subsequent course of
" the shot, has great though less immediate interest; it appears certain that oscil-
" lation is started, and by no means certain that it is quenched, during the passage
" along the bore. I myself have the idea that the oscillation is only extinguished
" by the course of a long flight, and lends, at short ranges, spiral direction and con-
" sequent inaccuracy to projectiles from M.L.R. guns." This was noticed in the erratic practice at the "Glatton's" turret by the "Hotspur's" 25-ton gun and balanced shot at 200 yards' range.

That appears to me strongly to confirm the view that I have already put forward on this question—that the irregularity of which we complain in the powder is, in

some degree, caused by mechanical conditions in the cartridge, and by mechanical conditions in the shot; and I think those two points should not be lost sight of when we are investigating, in a scientific way and with scientific exactitude, the powder-pressure which results from the explosion of powders of various densities and of various moistures in our guns.

Captain SELWYN, R.N.: I should like to ask a question or two, as I am not very well informed on the subject, and some things that I have seen, lead me to wish for further information. I was at Spithead during the naval review close to the "Devastation's" guns when they were fired, and I saw a very considerable portion of the pebble-powder igniting as is flew along in the air, igniting sufficiently slowly for the smoke produced from each grain, to be seen as a little continuous cloud. I should like to know whether any experiments have been made in order to test what percentage of the charge in guns with cartridge and in shotted guns escapes unfired in our present guns? and if, as I understand the intention be to lengthen the guns in order to avoid that imperfect explosion of the large-grain pebble-powder, to what extent we are required to lengthen and increase the weight of our guns in order to meet a condition which it seems to me ought not to have existed if the thing had been studied from the first? I am quite sure every one here must feel that Major Morgan has given us a most lucid explanation, and one which shows how close an attention is paid to whatever difficulties may arise under certain requirements at our Government factories. At the same time, I confess to very strong doubts whether those difficulties ought to have arisen at all, if all the conditions under which damage might occur to the gun, and if all the conditions under which gases are generated from powder had been studied closely, and if, as the French say, we "had the courage of our opinions." Men make weak guns; they find them damaged by such powder as we have been content to consider the best in the world up to within a few years; they then, in order to compensate for the weak guns, call for weaker powder, slower burning powder, and they then find, as a necessary consequence, that they must resort to the practices of those nations which have always employed weak powder, viz., lengthen the guns in order to burn it. I do not view, I confess, with any degree of pleasure, the idea of lengthening the already weighty machines which we are obliged to use in throwing projectiles, and I am quite sure a little scientific study of the whole question of gas-pressures, of gas-generations in guns, of the conditions in which projectiles ought to exist in the bores of these guns, as Captain Dawson has referred to them, would lead us to reconsider the whole question of the existence of pebble-powder. That it is a danger and difficulty I am quite sure; it cannot escape, as it does, unconsumed without rendering our ranges to a certain extent uncertain, even if we could get a much greater accuracy of densities and velocities than is shown in any of these tables. I must say I was quite relieved when I came to that broken-up powder, and did see some little correspondence between the different experiments. As soon as the powder is broken up, it begins to correspond; while it is whole, it is the most erratic thing you can use. It goes from 26·4 up to 80, while it corresponds within 1103 all through with the inch cubes directly it is broken up. That teaches us a lesson that there is something in the breaking up which imports a new condition into the matter, and which we ought to study closely; and I should like to know what study is being given to the condition of guns fired with ordinary R.L.G. without unfavourable rifling, unfavourable charges, unfavourable tubes, steel tubes, not properly made as they are now. We have got our experiments, and we have got our damage when guns were certainly not nearly so well made as they are now. We got them, and we still get them, with a rifling which I have always objected to, and shall still continue to object to, as the very worst system that has ever been introduced to this Institution, except, perhaps, the multigroove bore and the Whitworth, both of which proved themselves too bad to be continued. I want to ask whether Major Morgan can give us any distinct measure of the percentage of powder-charge which in each case of shotted guns and blank guns is thrown away unburnt, and what is the possible change in ranges, whether in mortars or other guns, which can be produced from that cause, in excess of the natural inaccuracy of the piece?

Mr. J. S. MACKIE, Mem. Inst. C.E.: I do not rise as a powder-maker or a gunner, but having had some opportunities of occasionally visiting Waltham Abbey,

I wish to express my high opinion of the very great value of the improvements and researches which have been there carried out. I think that the question of gunpowder-making is not a question merely of how large a charge we can get into the gun, but it is a question also of uniformity of shooting, and it is only those who have experience of powder-works who can at all comprehend the multiplicity of interferences which come in to prevent the manufacture of a uniform powder. My own impression is, that the quality of the powder must necessarily vary from day to day in accordance with the varying degrees of temperature and moisture, and other atmospheric conditions. Under these circumstances, I apprehend it is only in large establishments where the products of different seasons can be perfectly mixed together so as to get a very important and large average, that you will get that uniformity of powder which is necessary for good shooting. That the grains will have to be made for the various classes of guns, is a point which I think must also be met, and not only with regard to the size of the guns, but with regard to the weight of the shot to be fired. Also it has been very clearly, I think, shown by Major Morgan in his paper in reference to the experiments, that the very condition of the surfaces of these grains has an important influence upon the ignition and conflagration of the powder. For my own part I look upon this paper as being the most valuable contribution to the subject of gunpowder which has ever been produced, and I think that Major Morgan's predecessor ranks next to him in the importance of his paper on gunpowder, the late Captain Smith. I must also say the improvements which have been made in the machinery for the manufacture of this pebble-powder have been very simple and also very effective, particularly that by which the machine is made to produce pebbles of uniform size, and also the simple mode by which the cakes of pebble-powder are divided down the centre. I must also say that I think the Committee on Explosives, and especially the general conduct of Waltham Abbey since Colonel Younghusband has been there, deserve the highest commendation. The researches going on there have already produced important results, and still more important results will hereafter be produced. The application of the density-meter for testing the density of the powder is an important thing, and Major Morgan has done well in showing very clearly that it is not only a question of density but of porosity, for that a small amount of moisture will largely affect the burning and explosive properties of the powder, especially when it affects the exterior, I myself know very well from experience in another direction.

Captain SELWYN: I may mention (as Captain Dawson has referred to the mixing of powder) as an interesting historical fact, that Benvenuto Cellini* in his work on the Siege of Rome, mentions that he showed the gunners at that date that by putting small and large grained powder together, they could double the range of the guns.

Mr. HAYCROFT, of Messrs. Hall and Sons: One does not like to let an opportunity of this kind go by, without saying a few words, though I have been rather too much interested in listening to Major Morgan when he was giving us details of those experiments, to have thought of having anything to say myself upon the subject, especially since from time to time whilst attending the proofs at Woolwich I have had opportunities of conversing with him, and have exchanged ideas again and again, and made frequent comparison of our experience as to the difficulties which have arisen in the manufacture of pebble-powder, and also as to the effects of density and of moisture to different degrees in gunpowder. All these make it almost unnecessary for me to say anything, simply because I can scarcely say anything new. One idea struck me while Captain Dawson was speaking, which it seems to me he has put in a somewhat novel form, but which has been fully realised, and which has been perhaps met to some extent by the size and shape of the grains of gunpowder. He alluded to the air-spaces in the interior of the charge, and also to divisions in the cartridge, which really, no matter whether you call them divisions or spaces, are simply an increase of space. That subject has had careful consideration on the part of gunpowder-manufacturers, and it has been one of our principal objects to

* Benvenuto Cellini, sculptor, poet, painter, goldsmith, and gunner, flourished in the 15th century, and is said to have been the man whose bullet struck the Duke of Bourbon at the siege of Rome, during which that Prince was killed in 1527.

allow of as much air-space between the grains as the exigencies of manufacture would allow. There are some specimens which have been produced with a view to this in particular. I speak now of pellet gunpowders which have been manufactured in almost every conceivable shape, some produced with ribs upon their sides in order that lying as they do compactly in the cartridge, there may be air-spaces between them, just meeting the idea which has been broached to-night. I have never seen, however, that there has been any advantage in the proofs of these various gunpowders; there has been perhaps lower pressure, but I have never observed that there has been anything commensurate in the way of velocity. I do not know that in any single case where pellet-powders have been tried in that way, no matter how much they have been designed to leave spaces between the individual grains, there has been in one single instance any acceleration of the velocity. In most cases, as in all pellet-powders, a very low pressure has been obtained, but at the same time a very low velocity. It has been a source of study for some considerable time as to how a powder could be produced which should be exactly suitable for the 8-inch gun, and at the same time for the 35-ton gun, and in order to get a powder that would be suitable for both guns, it would be necessary, if you were having the large grain, to have also a low density if you were to use it in an 8-inch gun. Then the question arises, if you are to have a powder of very low density, you must necessarily have a very violent powder, and a violent powder will not manifestly do for a 35-ton gun where the charge is 110, 120, or 130 lbs. But every practical gunpowder-maker knows that there is another feature which has not come into the discussion at all, and that is the hardness of the gunpowder. I do not mean density, there is such a thing as the hardness of gunpowder without density, and it is the hardness of gunpowder which resists inflammability to some extent. A hard gunpowder, low in density and consequently fit for the 8-inch gun, and by virtue of its hardness suitable also for the 35-ton gun was produced by Messrs. John Hall and Son, and called "Infant C." Major Morgan will recollect the many experiments which have been made with "Infant C," sometimes in the 8-inch, sometimes in the 35-ton. The pressure in the 8-inch gun and the velocity fall within the limits given to pebble-powder, although the cube itself was an inch every way; and the velocity of the same powder in the 35-ton gun was second to nothing ever tried, and the pressure 23 tons, which in so great a charge as 110 lbs. was very low indeed. I do not look for any gunpowder which shall meet the requirements of the service so far as the different sizes of the bores are concerned, unless these matters are taken into consideration, but the experiments which have been made with the inch cubes, lead me to believe that that will be ultimately about the size of the cube, which will come into use not only for the larger guns, but also for the 8-inch, and in my opinion that is destined to supersede altogether the use of what we call the ordinary service pebble. I need say nothing in reference to the particular mode of producing the grains, that is mere matter of mechanical detail. I do not see, after the experience we have had in the breaking up of the grains, that we have need to be troubled at all in reference to the production of grains of three inches cube. These difficulties will be got over by ingenious minds. But how far it is practicable to make a gunpowder uniformly hard, is a matter that I would not like to discuss just now. Differences of temperature have a great effect on the manufacture of gunpowder, and also the time of the year, for there is an immense difference between the facility of producing gunpowder in summer and in winter. There is very much that we do not know yet to be discussed in reference to the manufacture of gunpowder.

Captain O'HEA: I should like to ask if any experiments have been made with pebbles of different shapes, globular, as well as square angular pebbles.

Colonel SMYTHE: I may, perhaps, correct what appears to me an error in the remarks of the last speaker but one on the subject, when he spoke of the variation of pressure by the introduction of air space into the cartridge, and by the introduction of obstructions into the cartridge. I was President of the Committee which experimented on these matters, and in our minds the two things were entirely opposite in their action. The air-space was provided by the introduction of an empty cylinder, and by some various other modifications of the same idea. The obstructions to the passage of the igniting flame were simply provided by thin discs of

cardboard or thin paper, and whereas the air-spaces increased the length of the cartridge, when we got a satisfactory action, by about one-fourth of its whole length, these paper discs hardly increased the length appreciably. The result was to separate the two actions entirely, and I thought perhaps the way in which it has been mentioned by Captain Dawson had left a misapprehension on the mind.

Major MORGAN: With reference to the air-spaces, I may state that experiments have been made by the Committee on Explosives on the same subject, but they have not got results equal to their requirements. They may mitigate the violence of the explosion, and reduce the pressure, but, as a rule, there is also a reduction of velocity, and I do not consider that it is sufficient to make progress in one direction without taking the two together. We can reduce the pressure in various ways. Density alone will do it. If you look at this sample made at Waltham Abbey, 1·82, the pressure is reduced in the 35-ton gun to 2·5 tons, so that if we are contented with reduction of pressure, there is no difficulty whatever in doing it.—(Commander DAWSON: I stated that the reduction of pressure was with equal velocity in India. I have the report here.) There is no doubt there is a reduction of pressure with that particular powder, but we found nothing to lead us to believe that by pursuing the line of investigation that you suggested, we shall get better results than we have had with our pebble-powder. We can improve upon a large charge of R.L.G. in that way, but we cannot make it equal to pebble-powder. What we want is sufficient space to ignite the powder with sufficient and moderate burning, to prevent too high a pressure being obtained before the shot has moved a certain distance.

Then about the quantity of powder driven out of the gun. It is a mistake to suppose that the quantity of powder driven out of the gun is due entirely to the size of the grains or the density. You will find in R.L.G. in field guns that you get as much powder, I dare say, in proportion, blown out as you do with large grains: in fact I have been told by an Austrian Officer that with large cakes filling up the whole of the bore, even less powder was lost than when pebbles were used. It seems to me that if the grains be too small, some action takes place in the gun that jams the powder, and thus a portion does not get ignited. Undoubtedly, therefore, shortening the cartridge and increasing the size of the chamber is, as far as we know, an advantage.

The question of the varying pressures of the powder, which is referred to by Captain Dawson, has, I hope, been satisfactorily answered to-night. He asked if it was possible in the same lot to have different barrels, that will give exceedingly different pressures. Perhaps Messrs. Hall will not object to my pointing to lot 1399 of their powder, especially when I say I choose it as an example, because they are such good powder makers that they can afford to illustrate this. They have got over the difficulties of want of uniformity now, I am convinced, and they were the first who led the way to powder for big guns. "Infant pebble" was the name introduced by Messrs. Hall, and I am very glad to hear that there is some reason for the peculiarities of "Infant C." It was a mystery to me. I could not understand how "Infant C" could give such moderate results with such a low density, and with so much dryness, and Mr. Haycroft has not explained it yet. Perhaps he will take the first opportunity when we meet to give me a satisfactory explanation. Still I may say "Infant C" has been excelled; I think I may point to Infants A and B. No better powder was ever fired from the 8-inch gun than Infant B, giving 1,480 feet velocity, with only 11 tons pressure; and if we add the necessary correction of 30 feet, there is 1,510 feet velocity, and, say about 12 tons pressure. I do not think a better shot was ever fired with the 8-inch gun than with that powder. The only way in which I could account for the action of Infant C was by supposing that the charcoal had been burnt very hard, and imperfectly ground, and perhaps this is the sort of hardness which Mr. Haycroft refers to, and is quite a distinct quality from the so-called crystalline texture, supposed by some to be produced by moisture.

With regard to uniformity of powder, I may mention for the satisfaction of Captain Dawson, that the gun factories used to find such exceedingly different results in the proof of guns, that they requested Waltham Abbey to furnish them with a batch of powder that was perfectly uniform, and of the highest pressure to be used for proof of guns. Lot 1970 was sent, and it has quite satisfied the gun factories with regard to uniformity of results. Two lots were taken and systematically mixed, and the

result is perfect uniformity, but unless you mechanically mix the whole batch, even should it be of the same stoving, you *might* get 20 tons pressure in the 35-ton gun with one round, and 60 tons with another. I think I have stated as much in a previous lecture here. I beg to say on behalf of gunpowder, that I think its capabilities are so great, that you can make it quite uniform, but yet, unless you are very particular with it indeed, it will show you all the discrepancies that Captain Dawson refers to which he would put down to the rifling. This is not the time to discuss questions of rifling. I entered into that subject on a previous occasion, and I am not anxious to take it up again to-night.—(Captain DAWSON: It is the fault of the manufacture of the gunpowder.)—It is the fault of the manufacture of the gunpowder, and this is one of the points that I wanted your attention to be drawn to to-night, viz., the improvements made in this respect. I may, however, say one word about the bursting of guns in front of the chamber. In some evidence which was given before an American Commission, one of the questions which received consideration was, why the guns burst so far forward. Why do they not burst in the chamber. Captain Dawson thinks it must be the shot, but they concluded it was due to the rush of the gas over the shot, which heated the surface of the bore, and that it was the expansion thus produced that did the mischief. I may state that in the proof of pebble-powder all the firings of samples are from a smooth-bore gun, so that there is no question of rifling whatever. We want to divest the question of manufacture of gunpowder as much as possible of other questions connected with artillery, but the question raised by Captain Selwyn is an important and a difficult one, and can only be answered satisfactorily by experiment. We must assume, I think, that the violence of the explosion is so great, that unless it be progressive, and relieved by the motion of the shot, no gun would withstand it. There must always, therefore, be a waste of the powder to insure the safety of the gun. My belief is that the pressure of powder exploded in its own space, and not relieved by expansion, is 150 tons per square inch, or even more. Some experiments have been made with the same powders in the 35-ton and 38-ton guns, which differ in length by 3 feet. The velocities differ by nearly 100 feet, but some of this difference is due to difference of windage.

The CHAIRMAN: I have only to finish my duties as Chairman by conveying your thanks to Major Morgan for his very interesting lecture. I may just say that it is a matter of great regret to myself that an artillery officer of long experience, who is in a high official position, was unable to take the chair this evening, because he would have been naturally able to have given his opinion on what we have heard much better than I can do. But, however, I may say this much, that I think even to outsiders it must be evident that this question of the manufacture of gunpowder is an exceedingly intricate one, and that it evidently depends upon a manipulation of details, and upon a knowledge of details, and likewise upon a number of circumstances which, as far as I can judge from what I have heard, require a great deal of further experiment and further investigation, and a long practice and experience. I am sure we may safely conclude from what we have heard from Major Morgan, that what is done at Waltham Abbey is being done in the right direction, and that in all probability he and Colonel Younghusband and others, who have taken up this very important question, will in time be able to elucidate all those facts which at present seem rather obscure, and we shall, perhaps, some day come to an end of the long controversy as to whether the anomalies that are apparent in some of the experiments are due, as Captain Dawson thinks, to the rifling and studs, and so on, or to the manufacture of the powder. I will only, in conclusion, thank Major Morgan, in your names, for his most able lecture, which I am sure will be a valuable contribution to our Journal.

LECTURE.

Friday, April 24, 1874.

COLONEL SIR HENRY R. GREEN, K.C.S.I., C.B., in the Chair.

THE RUSSIAN CAMPAIGN AGAINST KHIVA, IN 1873.

By Captain F. CHENEVIX TRENCH, F.R.G.S., 20th Hussars.

BEFORE proceeding to describe in detail the operations of the Russian troops in their recent successful expedition against Khiva, in the spring of last year, it will, I think, be as well to give a very cursory description of the country which was the theatre of operations, and to point out the circumstances and conditions which rendered the execution of such a project peculiarly hazardous and difficult.

The Khanate, or province of Khiva, is an Asiatic kingdom of considerable extent. The inhabited portion of it, which may, on a rough estimate, be said to be some 400 square miles in extent, owes its cultivation entirely to the irrigation effected by means of canals from the waters of the Oxus, which flows throughout the whole length of the Khanate, and is renowned throughout all Central Asia for its general fertility and productiveness. As is usually the case in Central Asia, this fertility extends just so far as the beneficial influence of this irrigation is felt on each bank of the river, and no further. Forming thus a green oasis in the midst of the arid steppes of Turkestan, the Khanate of Khiva, had, previous to 1873, ever been renowned, even among the *terræ incognitæ* of Central Asia, for its utter inaccessibility to the route, and more especially to the European world. The few European travellers and envoys, most of them (with a few exceptions) sent by Russian Governments, who had at rare intervals managed to reach the capital, and (what was more hazardous still) to return in safety, brought back accounts which tended fully to confirm all that had been heard of the dangers and difficulties of the journey. From the north, the south, the east, and the west, wide tracts of sandy desert, and sterile waterless steppe, literally hundreds of miles in extent, have to be crossed, ere the irrigated and habitable portion of the province can be reached. The difficulties of traversing these deserts are much increased by the nature of the climate and of the soil. During winter, in the more northerly parts of the steppe, such as that north of the Emba Fort, the ground is covered with snow, and overwhelming snow storms, which bury all

traces of the existing tracks and customary routes, are of frequent occurrence. In spring and autumn this same ground is often knee-deep in mud, whilst in summer, the steppe is everywhere burnt up with parching heat and blinding dust. The merchants, who every year traverse some of these routes in well equipped caravans, invariably suffer the greatest hardships, and often lose more than half their men and camels *en route*.

If such, then, were the difficulties encountered by small bodies of merchants who travelled with all available accessories, and who in many instances were traversing a friendly country, in penetrating to Khiva, it is evident that for a considerable force, numbering some thousands of men, and accompanied by all the necessary artillery, baggage, stores, and impedimenta inseparable from an expeditionary column, and who would necessarily be hampered *en route* by having to adopt every military precaution, these difficulties and perils would be tenfold enhanced. Nor were the difficulties confined to the perils of crossing the desert only. Supposing that the Russian columns succeeded in reaching the cultivated portions of the Khanate, it was known that they would find themselves in an enclosed district, thickly interspersed with wide and deep canals, where an active and enterprising enemy might, by destroying the bridges, and everywhere inundating the country, delay indefinitely the progress of all or any of the columns in their advance on the capital.

With regard to the causes that led to a declaration of war by Russia against Khiva, it will here suffice to remark that the rulers of the latter country had never, from time immemorial, been slow to avail themselves of the exceptional nature of the position of their territory, or to make the most of their cherished privilege of barbarous isolation. Secure in their fancied inaccessibility from attack, and conscious that it required a very long arm to reach them, successive Khans had for generations past, in their intercourse with Russia, set all the ordinary laws of nations at defiance. The subjects of Russia were habitually kidnapped and sold into slavery, her merchants were imprisoned, and their goods were confiscated, her envoys insulted, and treaties solemnly entered into were set at defiance. Nor were these barbarous rulers without some warrant for supposing that they could thus act with impunity. Only upon two occasions within the last 160 years, had Russia, in spite of much provocation, endeavoured to make felt the weight of her arms. Both of the expeditions fitted out for this purpose, viz., that of Bekovitch, in 1716, and that of Perovski, in the winter of 1839–40, had resulted in miserable and disastrous failure. The failure of Perovski's expedition, however, in which some 2,000 to 3,000 men are said to have perished in the snows of the desert, served its purpose in one way, for it pointed out to the Russian Government the mistakes and dangers which were to be avoided in any subsequent expedition that might be undertaken. As I have already remarked, it would be foreign to the scope and object of the present lecture to discuss the actual and immediate circumstances which induced the Russian Government to organise another expedition against Khiva in the spring of last year. It will be enough to say that the cup of Russia's

patience had long overflowed; that the project had been contemplated for some time, and that it was fully and amply justified by the provocation that had been received.

Before proceeding further, it will be well to consider more closely the difficulties and obstacles which, if the campaign was to be a success, would have to be overcome. These may be briefly summed up as follows:—

The conveyance of a force of sufficient strength across barren steppes, by various routes (of which the shortest was more than 400 miles in length), so that the troops should be in good fighting condition on reaching the cultivated and inhabited portion of the Khanate.

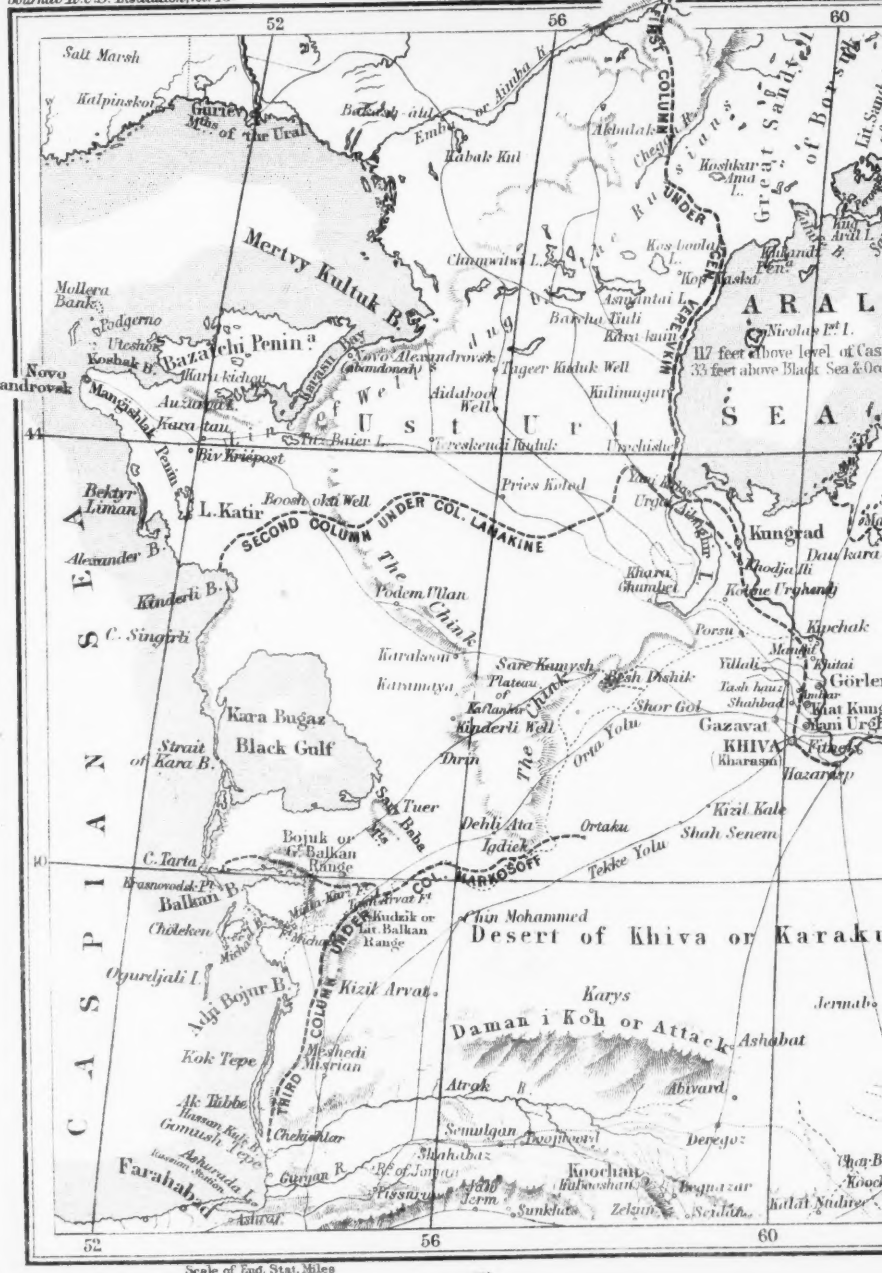
To select the most fitting time of the year, so that the troops and baggage animals should suffer as little as possible from the inclemency of the climate, and the great scarcity of water and forage *en route*.

To organise efficiently the enormous amount of transport required for a march through an utterly unproductive country, where every pound of forage and rations, and in some parts every drop of water for man and beast, would have to be carried with the troops.

With regard to the first point, the conveyance of the force and its necessary food, and the best method of taking it through the desert, I may remark that in all military operations in Central Asia, you are primarily confronted with this problem, that if you take with you a small force, you are liable to be beaten, and if, on the other hand, you take a large one, you are liable to be starved. It was recognised from the first that, owing to the scarcity of water, it would be impossible to take any considerable number of troops by any one route. In addition to this, if the columns were above a certain moderate strength, the trains of baggage animals would have been of such enormous extent, that it would have been impossible to protect them from the attacks of the Turkomans, who would be for ever hovering on the flanks of the column. Fortunately for the Russians, their facilities for approaching Khiva in more than one direction were far greater in 1873 than they were in the time of Perovski, some 35 years ago. Owing to her gradual and constant acquisitions of territory, her frontier lines may be said to have encircled Khiva, at any rate on three sides, and she could therefore dispatch columns from Orenburg in the north, from the shores of the Caspian in the west, and from Russian Turkestan in the east. Accordingly it was resolved, that the expeditionary columns should be four in number. Their times of starting were duly arranged with respect to the distance that each force would have to traverse, and they were all to converge upon Khiva. It was hoped by this division of forces to minimise the difficulties of crossing the steppes, and even if, as in the case of Perovski, one or two of the columns should from any cause be unable to penetrate the desert, it was thought that the others would arrive at their destination, and accomplish the objects of the expedition.

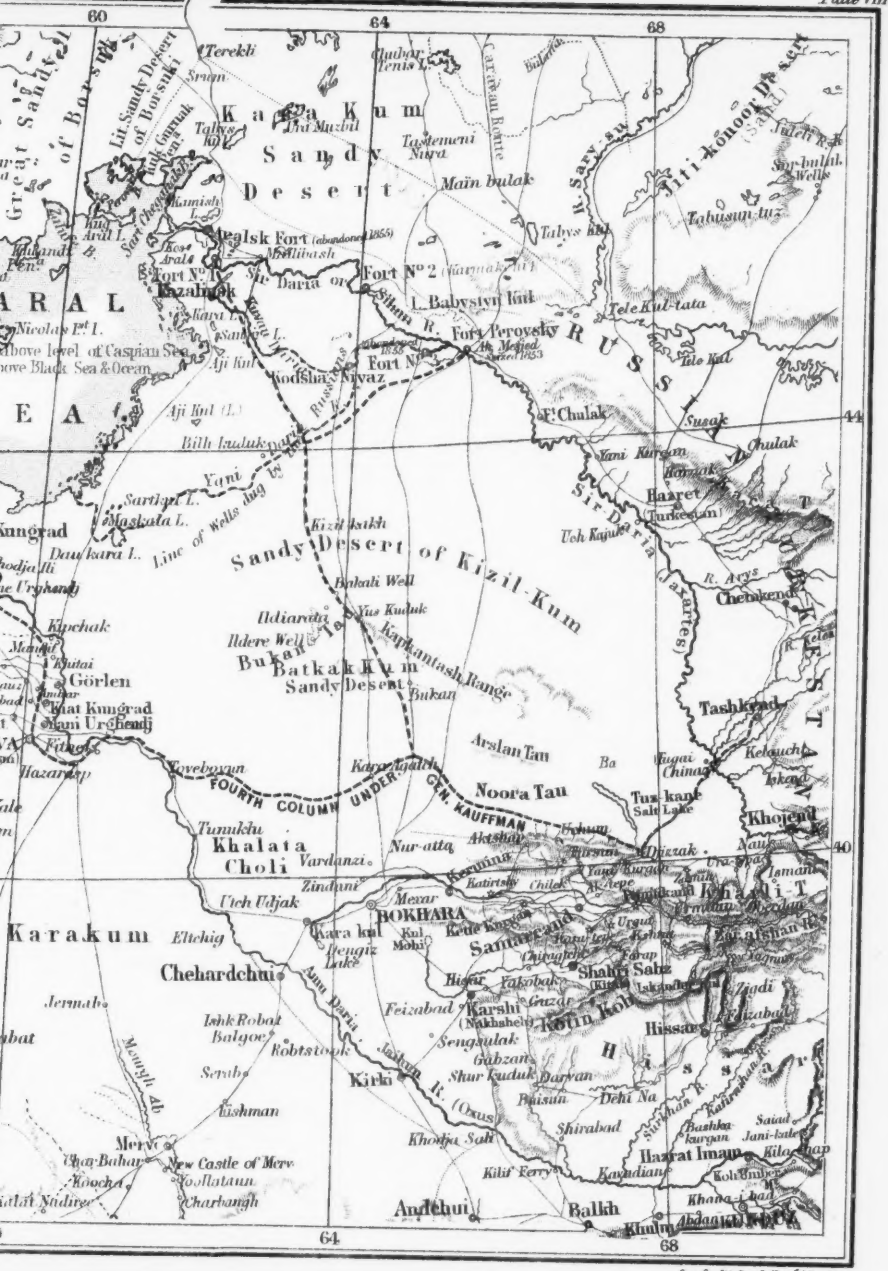
Secondly with regard to the time of year chosen as most fitting, it may be noted that Perovski started in mid winter, in order to obviate by the abundance of snow, the want of water in the steppe. As, however, the severity of the cold proved the principal cause of his disaster,

THE RUSSIAN Embuscha CAMPAIGN A



PAIGN AGAINST KHIVA IN 1873.

Plate VIII.



Stanford's Geogl Estabt London.

the spring was chosen as the best season, as it was found that there would then be more likelihood of finding water in the wells.

As the projected campaign, like our own expedition in Abyssinia, resolved itself entirely into a question of transport, this became the most important consideration of all. If a sufficient number of camels could be got together (and these were the only animals that would in the long run be found suitable for the work) and could be maintained in health while the troops were crossing the deserts, the success of the expedition might be anticipated with reasonable hope. If, however, the camels were to perish too fast, or should they become weakened and disabled from want of sufficient water, or excessive work, then the failure of the expedition was almost a certainty.

With regard to the resistance that the columns were likely to meet with, both during their march through the deserts and on entering the Khivan territory, it was not probable, judging from all past experience of the Russians in Asiatic warfare, to be of a very formidable nature. The regular forces of the Khan, both artillery and infantry, were known to be of no account. The force of irregular cavalry, however, at his disposal, was numerous, viz., some 15,000 or 20,000 horsemen. These men, as well as the various tribes of Turkomans who would be met with *en route*, were accomplished marauders, and indefatigable irregular troops, who would be sure to hang upon the flanks, and to harass the Russian columns constantly on their march.

I will now proceed to describe in detail the routes taken by the four expeditionary columns.

The 1st, which was to march upon Khiva from the north, took the same route as Perovski did in the winter of 1839–40. Taking Orenburg as its base of operations, its route lay in a southerly direction to the Emba Fort, and thence down along the western shore of the Aral Sea. The distance it had to traverse to Khiva was about 870 miles.

The 2nd column started from Kinderli Bay, on the eastern shore of the Caspian, and marched in an almost due easterly direction through the steppe, with the intention of joining the Orenburg force at or near the south-western corner of the Aral Sea. The distance which it had to traverse from its starting point to Khiva was about 485 miles, a great portion of the march lying through an almost entirely unexplored desert.

The 3rd column started from Chikislar and Krasnovodsk. The route which it had to traverse, a great portion of which lay through a totally unknown desert, lay in a north-easterly direction. The distance from the shores of the Caspian to Khiva by this way was about 550 miles.

The 4th column was to march upon Khiva from the east. It started from Tashkend and Djizak, and marched in an easterly direction. The distance which it had to traverse was estimated at about 540 miles. A supplementary detachment of this column also started from Kazalinsk. It was to march southwards to the Boukan Hills, where it was to join the Tashkend column.

The whole of the forces were under the orders of General Kauffman,

who was entrusted with the chief command of the expedition. The aggregate strength of the troops which he had at his disposal when the columns first started on their march was as follows:—

53 companies of infantry.
25 troops of Cossacks.
54 guns of different calibres.
6 mortars.
2 mitrailleuses.
3 rocket batteries.

All these made up a total of about 14,000 men, for whose transport as many as 19,200 camels were collected. All the columns were intended to unite about the middle of May, and to undertake combined operations against Khiva.

Having enumerated the different columns, and shown the routes they were to take, I will now go on to comment upon the general equipment of the troops, and then proceed to describe the doings of each force somewhat in detail, taking them in the same order as before. With regard to the equipment, I may say that no expense, trouble, or pains were spared in order to ensure the health and efficiency of the troops, and to render the expedition generally a success. Owing to the immense distances which they would have to traverse, and to the fact that at any rate two of the columns viz., those from Orenburg and Tashkend were to commence their march while it was yet winter, it was evident that the men would pass through great variation of climate, and have to undergo great extremes of heat and cold. Hence it became necessary that each soldier should have a double equipment, *i.e.*, one for winter and one for summer. This was rendered further requisite by the fact that even in many parts of the steppe where the heat was greatest in the day the nights were damp and cold. These facts rendered necessary an increase in the very thing which it was most desirable to avoid, viz., bulk of transport. The troops, therefore, generally marched in their lighter equipment by day, whilst their furs and blankets were carried on the camels' backs.

The tents were of the French "*tente d'abri*" pattern, except those of the Staff, which were of felt. In order to counteract the great scarcity of water *en route*, a number of Norton's tube-pumps were taken with each force.

A trestle bridge, for the purpose of crossing canals and streams, formed part of the equipment of each column, whilst a pontoon train accompanied that of General Kauffman.

The main article of diet of the troops, in addition to a small quantity of meat, was the Dolgorouki biscuit. These biscuits are about as large as a man's hand, and may be eaten cold as they are, or dissolved in water, either as cold or warm soup. These were invented by Prince Michael Dolgorouki, and their ingredients consist of flour, beef, and sour krout in equal parts. The Russian *Military Gazette*, in speaking of this biscuit, attributes the remarkable immunity of the troops during the campaign from fever and other diseases, by which men on such expeditions are usually attacked, to its general use. These biscuits

have, in fact, become as popular in the Russian Army as the famous "Erbwurst" among the German troops.

The Orenburg column, which was commanded by General Verevkin, was composed of about 2,100 effectives of all arms. The detail of it at starting was as follows:—

9 companies of infantry.
9 sotnias of Cossacks.
8 guns.
4 mortars.
1 rocket division.
5,000 camels.

At the latter end of February, the column, fully equipped in every respect, started from Orenburg, Orsk, and Uralsk, for the Emba Fort. The snow lay deep on the ground, and to facilitate the march, the guns, as well as two battalions of the line, were transported on sledges as far as the Emba, while the horses belonging to the guns were led. During this first half of the march, the troops were enabled, to a small extent, to draw upon the resources of the country, as they were able to buy from the inhabitants fuel, hay, and some few provisions of other sorts. As, however, during the latter part of the march, *i.e.*, from the Emba Fort till they reached the banks of the Oxus, no supplies of any kind could be relied upon, large stores of every kind were concentrated at the Emba Fort for the troops to take with them. Provisions were carried for 80 days, and further stores were sent on to the promontory of Urga, where it was intended to erect a fort. The provisions taken with the column, together with those sent after the column, were sufficient to maintain the troops till the end of September. In some places the ground was so deep with snow, in others so torn with fissures and ruts, that the troops were often unable to proceed for hours. However, on March 30th, in spite of all difficulties and obstacles, the whole expeditionary force was assembled at the Emba Fort, in good health and condition, except that both officers and men suffered much from blindness and inflammation of the eyes, brought on by the dazzling whiteness of the snowy steppe. On the 8th April the advanced guard marched from the fort southwards, and on the 14th May, the column arrived at the Urga Promontory. The line of communication with the rear was kept up by leaving small detachments at convenient points *en route*. Up to this time the column was quite unmolested by the enemy. On the 20th May it arrived before the walls of Kungrad, which city was, after a few trifling skirmishes, occupied without serious opposition from the Khivan troops. On the 21st May, leaving Kungrad, it continued its march further south. Continual petty skirmishes now took place with the Khivans, whose irregular cavalry perpetually harassed the Russians *en route*. On the 24th May, General Verevkin was joined by Colonel Lamakine's column, which had started from Kinderli Bay. The united forces then moved on to attack the fortified town of Khodja Ili, which was occupied by a strong body of the enemy. This place, after a somewhat serious engagement, in which the Khivans attempted to

meet the Russians in the open field, was taken and occupied on the 27th May.

A halt of two days was here made in order to refresh the troops after the fatigues of their long march, in the cultivated and fertile districts of the country which they had now reached, where forage, food, and pasture were found in abundance. On the 30th May the march was continued parallel to the left bank of the river, upon Mangit. No news had yet been heard of General Kauffman or of Colonel Markosoff's troops.

Upon the 1st June, the column, after crossing several large canals, reached at length the banks of the Oxus, at a place called Djelan-Tcheganak. On the 2nd June, Mangit was, after another rather obstinate contest, occupied by the Russian troops, and burnt. The loss of the latter, upon this occasion, was about 10 men killed, and some 30 or 40 wounded. The losses of the Khivans, however, are said to have been so heavy, that they abandoned all hope thenceforth of opposing the Russians in the open field. On the 4th June, General Verevkin still advanced, fighting his way as he went, and with some difficulty holding his ground, owing to the great superiority in numbers of the enemy. On the 5th, he received an embassy from the Khan, asking for an armistice, which was, of course, refused. The troops were, on this day, stopped for a night by a broad canal, the bridge over which had been burnt by the enemy. In order to obviate for the future any further delay from this cause, Colonel Leontschew, with a strong force of cavalry, swam across the stream, and pushed forward to occupy the bridges in front. He returned at nightfall with the news that the Khan had retreated to the capital, there to make a last stand with all his available strength.

On the 7th June came the first news from General Kauffman and his column. The letter which came, stated that he had defeated the enemy wherever he had met him, and that, on the date of the letter (June 3rd), he was himself on the left bank of the Oxus, and engaged in transporting his troops across from the other side. When he was ready to move forward, he would advance by Hazarasp on Khiva. Meanwhile, General Verevkin's column arrived on the 7th June to within four or five miles of the capital. At this point I will leave him for the present, in order to give some account of the operations of the other columns in their march through the steppe.

Colonel Lamakine's force, which marched from Kinderli Bay, was equipped at Tiflis. It consisted of two parts, one being composed of the troops who were to form the actual expeditionary force, and the other of those intended for the establishment and protection of certain fortified points, which it would be necessary to hold on the line of communication.

The former made up a force of about 2,200 effective men, with ten pieces of artillery.

Its detail was as follows:—

12 companies of infantry.
1 sotnia of Cossacks, 150 strong.
2 sotnias of Tartars, at 120 men each.

10 guns of different kinds and calibres.
1 rocket division.
1,300 camels, and 420 horses.

The column took with it food for 45 days. The cavalry carried five days' rations on their horses' backs, the rest upon camels. The troops started from Kinderli Bay on the 10th April, marching by different detachments in echelon for reasons of convenience, and also on account of the scarcity of water. They marched morning and evening only, owing to the intense heat, and pressed on at the rate of 20–25 miles per day. The sufferings and hardships which they had to undergo during their march through the desert, were oftentimes intense. The temperature ranged from 120°–150° Fahrenheit, the hot desert wind swept over the steppe like the blast of a furnace, whilst almost constant driving clouds of hot prickly sand filled the mouth, ears, and nostrils, and produced a maddening irritation and thirst as the men toiled through the deep sand. If to this be added the scarcity and bad quality of the water *en route*, which was almost always black and often salt and undrinkable, and the total want of any protection against the burning sun and the blinding glare, it must be admitted that the troops had no small difficulties to contend with. But the Russian soldiery, with that hardihood in which they may have but few equals, but certainly no superiors, resolutely held on their way, traversing even in that fearful heat long distances every day. To cross the desert and to reach the cultivated portion of Khiva, *coûte qui coûte*, was their aim and object, and resolutely they set themselves to the task. The cost of material at which their progress was achieved, was shown by the hundreds of dead baggage animals that day after day strewed the line of march. Fortunately a detachment of the column captured a large number of camels from the marauding Turcoman tribes on the march, and they were thus enabled to make good the deficiencies occasioned by those who perished by the way. In some places, where the wells were 40 or even 50 and 60 miles apart, every drop of water had to be carried in skins and casks upon the camels, and each man and beast received a stated allowance only once a day. Some of the wells, moreover, were poisoned by the Turcomans, and the water in each had to be tested by chemical means ere it could be issued to the troops.

It was found advisable to have a small number of unladen camels in order to carry the men in rotation during a portion of each day's march, and to take up those who fell out exhausted. In order to give an idea of the privations to which the Russian troops were exposed, and to show, moreover, on what a very slight thread hung the success or failure of the whole column, I will here narrate an incident that happened during this march of Colonel Lamakine's force. At the halt on the 9th May, the expected supply of water failed, and neither on that day, nor on the morning of the 10th, could man or beast be watered. Nevertheless, in spite of the burning heat, the march was continued. At noon, the horses of the cavalry were so exhausted, that most of them could scarcely move onward a step. Numbers sank powerless to the ground, and the riders lay gasping by their sides. Even the officers of the Staff began to despair of being able to march further, or of being

saved at all, as 30 long miles intervened before another well could be reached. The scene is vividly described by a Prussian officer* who accompanied the Expedition, and I therefore give it in his words. He says:—

"Colonel Lamakine commanded the halt, and all, even the officers "themselves, sank down by the side of their horses on the burning "sand. Not a drop more water in the column as far as the eye could "reach, nothing but the desolate waste of sand—sand all around, with "its burning, blinding glare; not a blade of grass, not a plant, not the "smallest insect could here exist. My servant and interpreter had "dropped behind hours ago, their horses had fallen, they themselves "lay powerless in the sand. I had scarcely remarked their absence. "As regards myself, my senses seemed beginning to vanish. We all "thought that the long-foreseen, the so long dreaded moment which "was ever before us, when we should all perish of thirst, had at length "arrived. At this critical moment, two wild figures are discerned "urging their horses towards us on the distant horizon; water, water, "is gasped out from every mouth—up, there is a spring in the neigh-"bourhood. Saved! Saved! is the expression that is visible on each "despairing face."

Colonel Lamakine had, in a moment of direst need, by accident, discovered a dry watercourse. Thinking, as is often the case, it might lead to a spring, he had sent two Kirghis to explore it, who had actually about three miles and a-half to the north, discovered a small spring, which was unknown even to the Kirghis guides. Thus the column was saved on this occasion from perishing by thirst.

Nor was the main body of Colonel Lamakine's force the only one that was in danger from the same source during that day's march. A detachment of the same column, which was advancing by a parallel route, was also arrested midway and lay stranded in the middle of the desert, unable from want of water to reach that night's encamping ground. Messengers arrived in the evening at Colonel Lamakine's camp with the terrible news, and with an urgent prayer for speedy help.

Instantly everything that could be filled with water was improvised for the occasion and loaded upon horses and camels, and all rushed back some three miles to rescue their perishing comrades. The water thus taken did not amount to much per head for man or beast, but, small as it was, it sufficed to enable the column to reach that night's halting-ground. Pushing on thus constantly at high pressure speed, and in frequent peril of perishing by thirst, the Kinderli Bay column marched steadily on.

On the 16th May, the first news reached it of the Orenburg force, for on that date, a despatch was received from General Verevkin, stating that he was steadily advancing, and that he hoped to be at Urga on the 20th May, at which place he directed Colonel Lamakine to join him, so that the combined forces might then march upon Kungrad.

* See "Aus Chiwa." Berichte von Hugo Stumm. Lieut. im 1 Westfälischen Husaren Regiment No. 8, attachirt dem Russischen Hauptquartier. Berlin, 1873. Siegfried Mittler & Sohn.

On the 20th May a subsequent letter arrived, in which the General sent news that he had already left Urga, and was advancing upon Kungrad, and that the Kinderli Bay column was to march upon that place. Thereupon the direction of the march had to be entirely altered. It was important that reinforcements should reach Verevkin before he came into contact with the main forces of the enemy, and it was uncertain at what point he could reckon upon falling in with the Kinderli Bay column. Under these circumstances Colonel Lamakine decided to divide his force, and to push on himself with his cavalry at all risks and hazards by one route upon Kungrad, regardless of the supply of water, while the infantry and main body of his column pushed on by another and more direct way. Starting, therefore at 9 A.M., on the 20th May, he, with his Staff and cavalry, marched by the route which you see marked on the map, and succeeded in catching up Verevkin's column a little beyond Kungrad on the evening of the 24th, whereas the infantry, who marched by a far shorter route, effected a junction with him somewhat earlier on the same day. This last advance of Colonel Lamakine's column to Kungrad was perhaps the most remarkable feat performed by any of the Russian troops throughout the whole campaign. From 8 A.M. on the 20th, till 2 A.M. on the 24th May, *i.e.*, in scarcely five days, the column traversed a distance of 120–125 miles. If we bear in mind that the whole distance was performed by the infantry in marching order under a burning sun; that not a drop of water of any kind was during three whole days procurable *en route;* that the water which was actually necessary for subsistence was carried in casks and skins upon the backs of camels; that this water was brackish and salt, and in many cases half putrid with long transport, and generally nearly boiling hot from the heat of the atmosphere; that each man's allowance of such water per day was only three-quarters of what his cooking pot would hold during the first two days, and during the third day only half that quantity, it will, I think, be owned that as a feat of marching this will vie with anything that any infantry have at any time ever achieved.

As soon as the column reached the cultivated districts their troubles as to water, forage, and grass were over, as everything of this kind was found in abundance.

I now turn to Colonel Markosoff's column, to see how it fared with him and his men. As is doubtless well known to many of my hearers, this was the only one of the four columns which failed to penetrate the desert. The column started from Krasnovodsk and Chikislar in the end of March.

It consisted of—

8 companies of infantry,
4 companies of Cossacks,
16 guns of different calibres,

eight of which were drawn by horses and eight by camels. These formed a total strength of about 1,500 men. For the transport of this force 3,000 camels were provided.

The troops appear to have fared well enough until they reached the

old bed of the Oxus, along which the route lay. All along the channel, the sand lay deep in high irregular ridges, so that the men soon became exhausted with the labour of marching. They were scorched by the fiery sirocco that blew in the day time, and which rendered the air one whirl of hot prickly dust. The little water which was found was not fit to drink, inasmuch as when the men, half mad with thirst, got to a pool, they found it salt. The heat was sometimes 150° F. in the daytime, and the nights brought with them no relief, for there was not a breath of wind. The horses of the column dropped fast, and the camels soon followed, so that all the men had to trudge on foot as best they might.

At Igdiek the monotony of the march was relieved by a fight with the Turcomans, who were utterly routed.

The troops, with that hardihood and endurance for which the Russian infantry is proverbial, held out as long as they could, but at length, when the column reached Ortaku, matters got to such a crisis that Colonel Markosoff summoned a council of war, at which it was determined to turn back, It was not a moment too soon. Out of the 3,000 camels that started, 800 alone survived; more than three-fourths of the horses had died, and those which survived could hardly put one foot before the other. Out of 1,500 men nearly 50 per cent. were unfit for duty, and the column had as yet scarcely gone two-thirds of the way. It was with the greatest difficulty that the remainder of the column got back to Krasnovodsk.

Though Colonel Markosoff failed, owing to adverse circumstances, to penetrate with his column a desert which, with the exception of Vambery, perhaps no European had ever traversed, his expedition was by no means barren of results. Owing to the diversion which he caused against the Yomud tribes on the Atrak, the destruction of their strongholds, and the dispersion of their forces, he held in check the best and most warlike allies of the Khan. Had it not been for his advance, the Khivan forces would have been stronger by some 10,000 men.

Finally it remains to deal with the strongest column of all, viz., that from Tashkend and Djizak, under General Kauffman, of which the Kazalinsk column may be considered as a supplementary detachment.

The detail of the Tashkend column was as follows:—

12 companies of infantry.
14 guns of different kinds.
2 mortars.
1 rocket division.
5 sotnias of Cossacks.
6,700 camels.

The Kazalinsk column consisted of—

8 companies of infantry.
6 guns.
2 mitrailleuses.
1 rocket division.
2 sotnias of Cossacks.
2,800 camels.

The main body of the Tashkend column, of which Major Golowatschow had the immediate command, began to leave Tashkend in detachments about the 3rd March. The weather was bitterly cold, and during the early part of the march, snow storms were of frequent occurrence. But by the middle of April, when they reached the barren sandy steppe, the climate had reached the opposite extreme, and it was here that the real difficulties and hardships of the march began. The heat was often intense; the sand was so fine and deep that the men sank into it at every step, while frequently it was with the greatest difficulty that the artillery horses could draw their guns through it. Whenever the wind blew, it raised such clouds of dust that the troops could only see a few yards before them, while at times, the sand storms came on with such violence that everything was enveloped in utter darkness, and the column was brought to a halt. Added to all this, water was so scarce that it had to be doled out and husbanded with the greatest care. Nevertheless, in spite of all these obstacles, the troops held on their way, and generally managed, by dint of the greatest exertions, to accomplish from day to day the marches that had been previously arranged. It was necessary to do this in order to accomplish the distance to the Oxus. The last part of the march, viz., that from a place called Adam-Krylgan to the banks of the above-named river, was the most desperate of all. Twice were the troops brought to an absolute stand-still in the desert through want of water, and were only saved by the timely discovery of wells and springs at some distance from the line of march. In one of these instances it was found that the water thus discovered was only sufficient for half the troops of the column, and all the cavalry and artillery horses and the camels had to be sent back one long march in order to remain near some wells, till arrangements could be made for their onward march. On both these occasions the situation of the troops was most critical. The camels perished by dozens; everything in the shape of baggage, except what was most rigidly and absolutely necessary, had to be abandoned in the desert (some of it was burnt and some buried), in order to lighten the loads of those animals who were able to proceed.

Time will not allow of my dwelling at greater length on the incidents of this march; I will therefore only say that the accounts of the hardships endured by the troops can only tend to raise our admiration of the Russian soldier to the highest pitch.

At length, on the 23rd May, General Kauffman's force reached the Oxus. Colonel Kolokoltzow, in his interesting diary of this march, describes the feelings of pride and exultation which filled the hearts of himself and his comrades, when, after all their toils and sufferings, they gazed upon this old-world-famed mighty stream, and reflected that they were the first European force that had stood upon its banks since the hosts of Alexander of Macedon quenched their thirst in its waters more than two thousand years ago. The Russian troops marched along the left bank and occupied Shurachan. Reconnaissances were then made of the banks of the river, with a view to cross over it. But how to effect this object was now the problem. The enemy in retreating had taken all the boats to the other side. The stream was from

400–600 yards wide, deep, and with a rapid current. The pontoons which the column had taken with it at starting from Djizak had all (with the exception of two) been of necessity abandoned in the desert. Fortunately there are men among the Russian troops who are quite capable of making the most of any chance that may present itself. A troop of Ural Cossacks, who had been pushed forward to reconnoitre the river, perceived, far out in mid-stream, one of the enemy's boats, which had stuck on a sandbank. The officer and ten of his men instantly determined to swim out their horses to the boat, which was more than 300 yards from the shore, and endeavour to capture it. Armed with their sabres, holding on to their horses' manes, they plunged into the rapid stream, and succeeded in reaching and capturing the boat, the inmates of which took to the water as soon as they saw them approach. A small armed party was then sent across the stream in this boat, who managed, in spite of the opposition of the enemy, to capture some 14 or 15 more boats from the left bank. By means of these, the passage of the whole force was effected, with but little opposition from the enemy, during the 2nd, 3rd, and 4th June. On the 5th June the town of Hazarasp, which is described by Colonel Kolokoltzow as being a large fortified place with high walls, was occupied without opposition by the Russian troops. During the 7th and 8th a halt was made here, in order to allow all the different detachments to come up. On the 10th June an envoy of the Khan came and tendered his submission, offering to surrender the capital. The events that happened on that day I will narrate in my continuation of the account of General Verevkin's operations.

We left General Verevkin on the 7th June within four or five miles of the capital. During that day and the 8th June, he was occupied in making reconnaissances and maintaining his position, which he had some difficulty in doing, owing to constant skirmishes with the Khivan troops, who harassed him incessantly, and who were well provided with artillery. As he had as yet no certain tidings of General Kauffmann, whose force, it was reported, had been compelled to retreat, owing to the want of provisions and transport, and as, moreover, the incessant attacks of the Khivans, who were greatly superior to him in numbers, tended to wear out the strength of his men, General Verevkin saw that any further delay would tend to endanger the safety of the column under his command. He therefore determined, without waiting any longer for the advent of the Tashkend column, at once to attack the city.

Accordingly, the necessary dispositions were at once undertaken to make a reconnaissance right up to the walls, to mount the necessary batteries, and to begin the bombardment at once. The ramparts of the city were found to present the appearance of a regular bastioned fortification, with numerous guns mounted on them, which sustained a well-directed fire upon any of the Russian troops who showed themselves. On the 9th June, a general advance against the northern side of the city was ordered. As the Russian troops went forward, the Khivan forces fell back on every side. At 12 o'clock, the Russian batteries were got into position, and the bombardment was begun, and

continued at intervals until the morning of the next day. The enemy's artillery at first replied briskly, but was silenced in the course of three or four hours. At length it was determined to carry the northern gate by assault. It was accordingly stormed and taken with a loss of some 15 killed and wounded. Meanwhile, General Kauffmann had arrived in the close vicinity of the city on the other, *i.e.*, the eastern side, and had received envoys from the Khan, offering to surrender the city. Consequently, the Russian troops entered it on the 10th June, having suffered a loss of some 107 men killed and wounded in the assault.

Thus, practically speaking, may be said to have ended the Khivan campaign of last year. It may well be said to have been a brilliant success, and I think most of my hearers will agree with me when I express an opinion that the conception and execution of the project reflect the highest credit upon those who planned, and carried out to a successful issue all its administrative details. With regard to the soldiers who executed it, all those who are capable of forming a trustworthy judgment on the subject will, I think, agree with me when I say, that though the Russian Army has made a name for itself on many a hard-fought field, there is nothing to which it may more justly point with pride than to the discipline, hardihood, and endurance which enabled its soldiers, in spite of such terrible obstacles as have been narrated, to traverse the Khivan steppes in 1873.

Complete, however, as was the success of the expedition, it should not blind us as to the slightness of the thread upon which hung the chances of success, or render us incapable of discerning how very easily the whole expedition might, like that of Perovski in 1839–40, have culminated in wholesale disaster and death. Had circumstances not largely favoured the Russian troops, or had the leaders of the Khivan forces been in any way capable of utilising the advantages presented by the natural and artificial features of the country, it may readily be seen how all the efforts of the former might have been rendered abortive. An epidemic among the baggage cattle; a successful raid by the marauding hordes of Turcomans upon the huge transport trains of any of the columns; the filling up of the very few wells in the desert upon which, literally, the very existence of the troops at times depended: all, or any of these, might have stopped the progress of the expedition. In addition to this, if the Khivans had destroyed the bridges over the numerous wide and deep canals which everywhere intersect the cultivated portion of the Khanate, instead of leaving them intact, as they generally did, or had they inundated, as they easily might have done, the whole country around the capital, any of the columns might have been indefinitely delayed, and even final success might have been rendered doubtful.

In conclusion, it may be worth while to note a few points of comparison between this expedition and some of our own recent campaigns; to compare the tactics employed by the Russians and ourselves; and very briefly to point out the conclusions we may draw from its success. The campaigns to which I refer, are, of course, those in Abyssinia and Ashantee, between both of which and the Russian expedition to Khiva a very close parallel may, in many points, be drawn.

1st. In all three cases, political circumstances rendered it necessary to reach the enemy's capital. In all three cases, moreover, the Governments sending the expeditionary forces were confronted with this dilemma, viz., that if a small force was sent, it would incur risk of defeat; if, on the other hand, a large one was sent, the great difficulties of supply would render it liable to be starved.

2ndly. In Abyssinia, also, our troops had, like the Russians in this expedition, to advance hundreds of miles through an utterly unproductive country before reaching their objective point.

3rdly. In all three cases, the actual fighting was, comparatively speaking, insignificant.

4thly. The similarity of the tactical method employed when, in Ashantee and in Khiva, the invaders found themselves opposed to a vastly superior swarm of undisciplined foes, is, perhaps, the most noteworthy parallel of all. In the principal action in Ashantee, our troops appear to have advanced with the main body arranged in compact junction, having its front, as well as its flanks and rear, arranged in loose, skirmishing order. By this means, the whole body was enabled to press on without much regard to the enemy's being on the flanks and rear. In the same manner, in Colonel Kolokoltzow's narrative, the Russian troops are described, when menaced by hordes of irregular cavalry, as forming their main body into a hollow square, with skirmishers thrown out to protect it on each side as it advanced. In this way, for instance, General Verevkin advanced during the 4th and 5th June in a continuous engagement or series of skirmishes. This might be considered as a close parallel to Amoaful.

5thly. It confirms the experience which we ourselves have already gained in Abyssinia and Ashantee, viz., that a well-equipped European force can, when the necessity for it arises, traverse successfully an utterly barren and unproductive country, even where the barest necessaries of life have to be carried with the troops.

Lastly. It has refuted for ever the arguments of those who, when questions of future Central Asian politics and strategy were discussed, were wont to deride the possibility of an European force crossing with safety any deserts and steppes which may intervene between them and such points as the Government who sends them, may, for political and strategical reasons, think it desirable to seize.

Evening Meeting.

Monday, April 20, 1874.

ADMIRAL SIR HENRY J. CODRINGTON, K.C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 31st March and 20th April, 1874.

LIFE.

Custance, H. F., Col. 1st Norfolk Militia.
Jones, H. Helsham, Major R.E.
Ramsay, J. W., Commander R.N.
Brown, Sir W. R., Bart., Col. 1st Lanc. Art. Volunteers.
Gataker, Henry W., Lieut. R.A.
Waldegrave, W. F., Earl, Lieut. London Rifle Brigade.
Stewart, Walter, Commander R.N.

ANNUAL.

Blomfield, Thos. E., Lt.-Col., late 25th Regiment.
Birley, R. K., Captain 19th Lanc. Art. Volunteers.
Gladstone, John R., Lieut. Coldstream Guards.
Gatacre, W. F., Capt. 77th Regiment.
Whitehouse, Alfred, Paymaster R.N.
Page, G. H., Col. 47th Depôt Brigade.
Rosser, George, Lieutenant, late 17th Lancers.
Pim, Henry R., Captain, late 3rd Huss.
Barclay, Alexander, M.D., D.S. General.
Halkett, F. J. C., Lt.-Col. 2nd Tower Hamlets Militia.

THE STRATEGIC IMPORTANCE OF THE MILITARY HARBOURS IN THE BRITISH CHANNEL AS CONNECTED WITH DEFENSIVE AND OFFENSIVE OPERATIONS.

By Major-General COLLINSON, R.E.

I FEEL that it requires some apology from me, being a soldier, for venturing to speak upon a subject which is rather more nautical than military; but I have endeavoured to treat it as something more than a purely technical question, and I hope that the advantage that may possibly be derived from hearing the subject from a soldier's point of view will condone for the want of nautical information that I shall display. I have had the advantage of consulting some Naval Officers of great experience, although I do not wish to make them responsible for the opinions that I am going to express. I should also like to take this opportunity of acknowledging, as I dare say many other gentlemen in my position have before me, the very great assistance and attention that I have received from the Officers of this Institution.

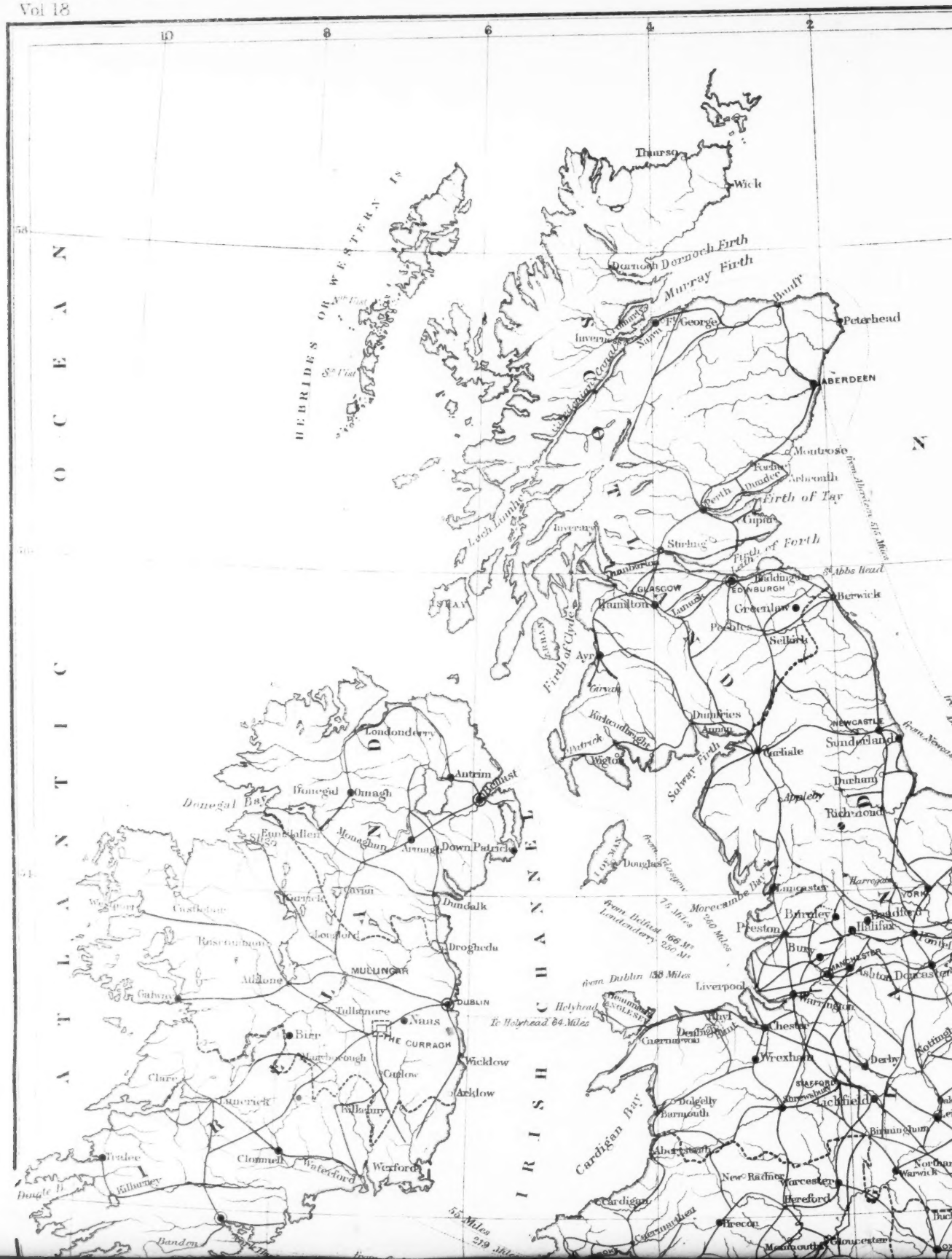
The first thing that struck me when I began to think about the question, was the very great change that has come over the feelings of the people of England in treating military questions. I recollect the time when war was believed almost to have disappeared—at least from Europe—when armies and navies were tolerated only as a kind of police, and even this Institution was looked upon as a sort of museum of obsolete weapons. But now nothing excites public interest more than the operations of the Army and Navy, and the very appa-

ratus of war has created for itself a business in the workshops of the country; and as to the discussions in this Institution, they are becoming household words. There are many people who think that this is a very grievous prospect, and I have no doubt there are some who treat it as a sort of outburst of professional zeal. Whatever the cause, and whatever the effect may be, there can be no doubt of the fact that not only with the English people, but in all Europe, war has become a subject of national concern to a degree that would have been considered thirty years ago as quite impossible, and I draw the conclusion therefrom, that whether war is possible or whether it is probable, at all events the English people are in a mood now, to look the whole consequences of war straight in the face. Having that sort of feeling, I put the first question to myself, What are the interests of Great Britain that would be affected by any great war? and I read a remarkable book which was written by a remarkable man in his day, Sir Charles Pasley, about the war policy of Great Britain in the year 1808. That book is quite worthy attention now, for although the particular illustrations in it are become obsolete, the principles themselves are those of a brave patriotic Englishman, and therefore they are suited to all time. It was written with the object of rousing the people of England to a better appreciation of their interests at stake in the war, and of the importance to them of taking a more determined part in it.

While reading his arguments, based on the interests of Great Britain, then concerned in bringing Europe to a state of peace again, I could not but contrast them with the interests she has now spread over all the world, far beyond anything that was imagined even in those stirring times. Their limited commerce—scarcely a recognised colony—Canada little known—Australia a mere penal settlement—India a mercantile firm—their long, uncertain voyages in sailing ships—the sea commanded it is true, but as an element to fight on.

Compare this with the Great Britain of 1874; a commerce multiplied a hundred fold, and extending over all the world; one empire in India, another in Australia, another in Canada; the ocean ruled for our commerce by huge iron steamers, reducing sea transport nearly to the certainty of land. And these interests not only increased and extended to Asia and Africa, but what is more important, having new responsibilities added to them. The Great Indian peninsula is dependent on us for its progress, the rising States of Australia and Canada draw from the mother country their inspirations of social and political life: all are looking to a close connection with the British Empire as a vital element of their strength; all are prepared to assist in preserving the integrity of that empire. If England was then mightily concerned in keeping the peace of Europe, what are now her interests in keeping the peace of the world!

It is these peculiar responsibilities attaching to our connection with our great dependencies that create a new feature in our interests over the world. When Pasley wrote, thinking only of opposing French domination, he urged that alliances should be made and a footing secured, in such maritimes States of Europe, as could materially assist us in controlling the power of Napoleon. And he pointed out that


10
8
6
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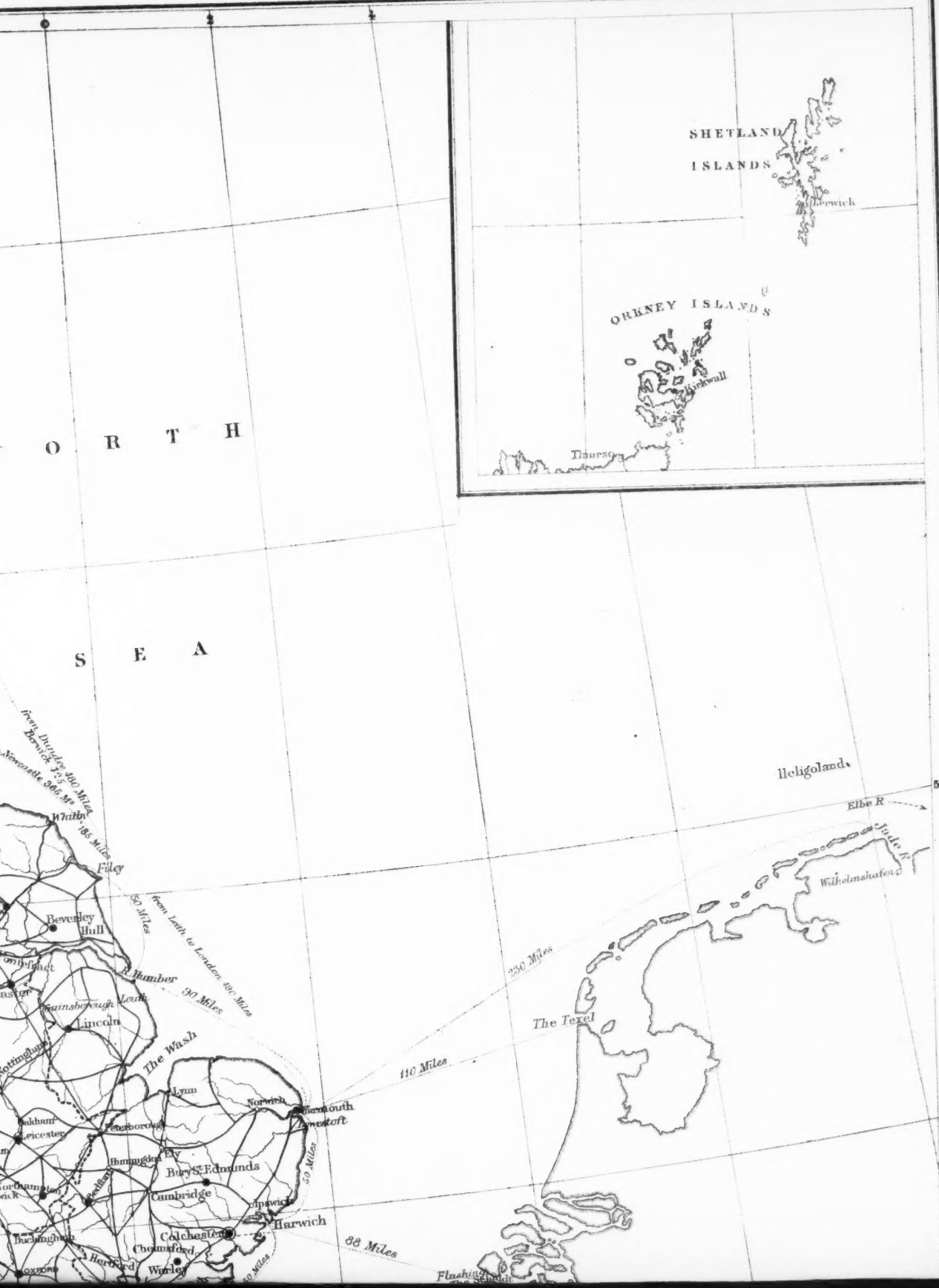
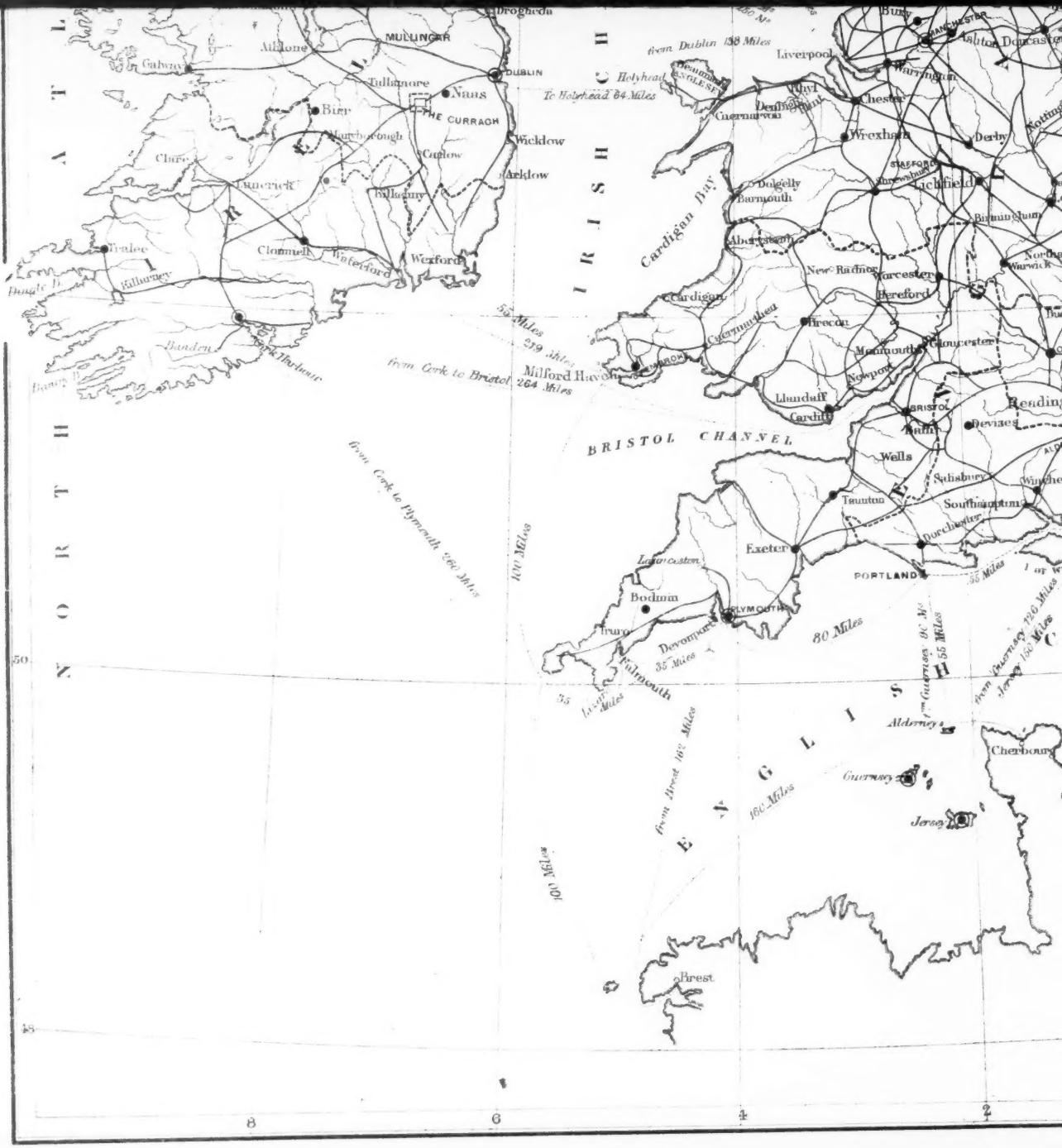
2
OCEAN
ATLANTIC
HEBRIDES OR WESTERN IS
St Kilda
St Kilda
Thurso
Wick
Dornoch
Dornoch Firth
Murray Firth
Inverness
Caledonian Canal
Nairn
Fr George
Banff
Peterhead
ABERDEEN
Montrose
Arbroath
Dundee
Perth
Firth of Tay
Loch Lomond
Crieff
Stirling
Firth of Forth
Inverness
Dumbarton
GLASGOW
Hamilton
Lanark
Paisley
Ayr
Firth of Clyde
Cairn
Kirkcudbright
Dumfries
Annan
Wigton
Carlisle
Edinburgh
EDINBURGH
St Abbs Head
Berwick
Greenlaw
Selkirk
NEWCASTLE
Sunderland
Durham
Appleby
Richmond
Solway Firth
Londonderry
Antrim
Donegal
Omagh
Donegal Bay
Enniskillen
Monaghan
Armagh
Down
Patrick
Sligo
Carrick
Cavan
Dundalk
Castlebar
Boyle
Longford
Drogheda
Ballinrobe
Athlone
MULLINGAR
Galway
DUBLIN
Tullamore
Naas
Birr
THE CURRAGH
Wicklow
Clare
Limerick
Cuglow
Arklow
Killarney
Tralee
Clonmell
Waterford
Wexford
Dingle B
Bandon
Cork
Douglas
Douglas
Lancaster
Morecambe Bay
Preston
Burnley
Bradford
Halifax
Bury
MANCHESTER
Liverpool
Warrington
Chester
Wrexham
Derby
Lichfield
STAFFORD
Birmingham
Dolgelly
Barmouth
Aberystwith
New Radnor
Worcester
Hereford
Warwick
Cardigan
Brecon
Monmouth
Gloucester
Cardigan Bay
Holyhead
To Holyhead 84 Miles
Dublin 138 Miles
Liverpool
Douglas
Glasgow
Belfast
Londonderry
75 Miles
260 Miles
166 Ms
250 Ms
55 Miles
219 Miles


SHETLAND
ISLANDS
Lerwick
ORKNEY ISLANDS
Kirkwall
Thurso
O R T H
S E A
Heligoland
54
Elbe R
Jade R
Wilhelmshaven
The Texel
52
Flushing
Schelde
Ivanis Dundee 190 Miles
Berwick 325
Newcastle 305 Mls
Whitby 185 Miles
Filey
Bevercley
Hull
50 Miles
From Leith to London 400 Miles
Humber
90 Miles
Lincoln
The Wash
Lynn
Norwich
Yarmouth
Lowestoft
110 Miles
250 Miles
Leicester
Peterborough
Ely
Bury St Edmunds
Cambridge
Ipswich
Harwich
50 Miles
Colchester
Chelmsford
Hertford
Watford
Buckingham
88 Miles
50 Miles


ATLANTIC OCEAN
IRISH SEA
NORTH SEA
ENGLISH CHANNEL
BRISTOL CHANNEL
Drogheda
MULLINGER
Athlone
Galway
DUBLIN
Tullamore
Naas
THE CURRAGH
Birr
Wicklow
Carlow
Arklow
Limerick
Tralee
Killarney
Clonmell
Waterford
Wexford
Bandon
Cork Harbour
from Dublin 138 Miles
Holyhead
To Holyhead 84 Miles
Liverpool
Chester
Wrexham
Derby
Dolgelly
Barmouth
Cardigan Bay
Aberystwith
New Radnor
Worcester
Hereford
Cardigan
Brecon
Monmouth
Gloucester
Newport
Llandaff
Cardiff
BRISTOL
Devizes
Wells
Salisbury
Taunton
Southampton
Dorchester
PORTLAND
Exeter
Launceston
Bodmin
PLYMOUTH
Truro
Falmouth
Devonport
35 Miles
80 Miles
55 Miles
55 Miles
Milford Haven
264 Miles
from Cork to Bristol
from Cork to Plymouth 266 Miles
100 Miles
100 Miles
160 Miles
from Brest 162 Miles
Aldernay
Guernsey
Jersey
Cherbourg
Brest
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48
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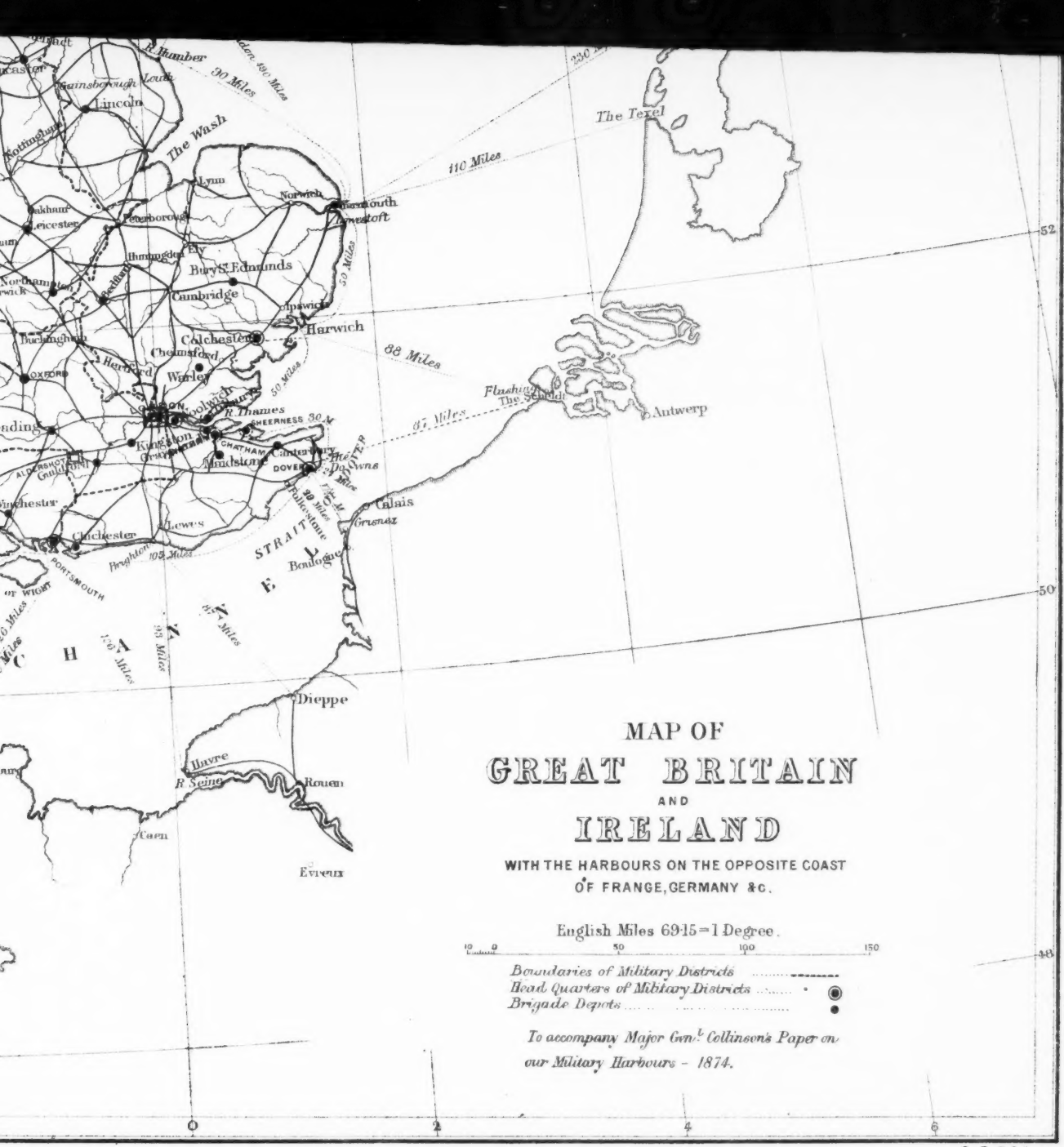


MAP OF
GREAT BRITAIN
AND
IRELAND

WITH THE HARBOURS ON THE OPPOSITE COAST OF FRANCE, GERMANY &c.

English Miles 69·15 = 1 Degree.

0 50 100 150

Boundaries of Military Districts

Head Quarters of Military Districts

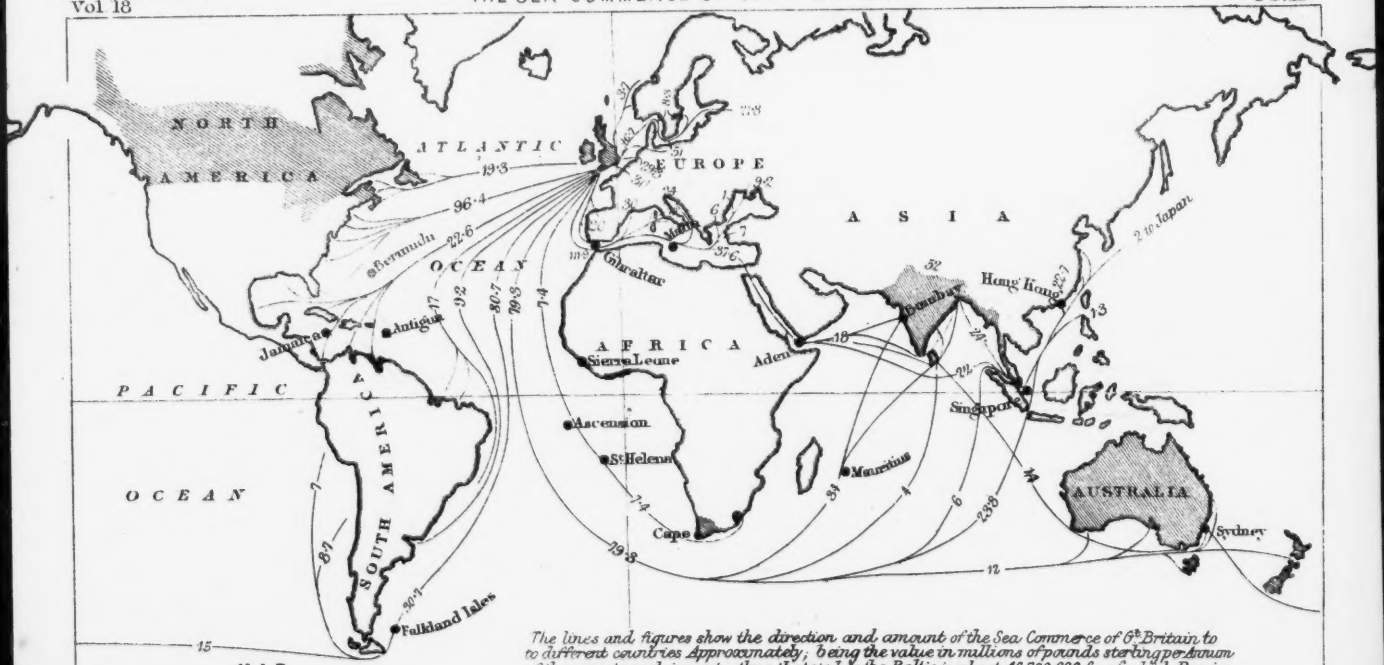
Brigade Depots

To accompany Major Gen.l Collinson's Paper on our Military Harbours - 1874.

J. Jobbins

Journal R.U.S Institution
Vol 18

THE SEA COMMERCE OF GREAT BRITAIN.


NORTH AMERICA
ATLANTIC OCEAN
EUROPE
ASIA
AFRICA
PACIFIC OCEAN
SOUTH AMERICA
AUSTRALIA
Bermuda
Gibraltar
Malta
Jamaica
Antigua
Sierra Leone
Aden
Bombay
Hong Kong
Singapore
Ascension
St Helena
Cape
Mauritius
Falkland Isles
Sydney
2 to Japan
19·3
96·4
22·6
32
80·7
29·3
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M. GENL COLLINSONS
Paper on our Military Harbours 1874

There is no precise information of the amount of [illegible] must therefore be considered as approximate estimates only

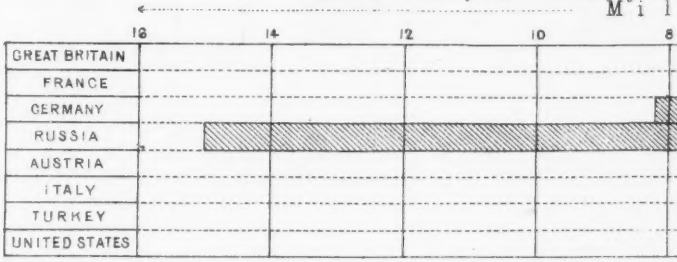
J. Jobbins

TABLES SHOWING THE WAR POWER AND THE FL

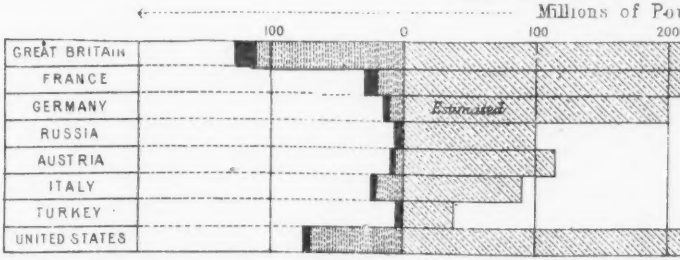
Taken chiefly from the Statesmans Year Book 1874 and from Dieleres Marine Cuirassees, and from a late publication by the German Statist. Dep^t. To Accompany

MAJOR GENERAL COLLINSON'S
Paper on our Military Harbours 1874.

The Male Population between the ages
The Military Forces, War Footing, exclusive of
The Seafareing Population, including War



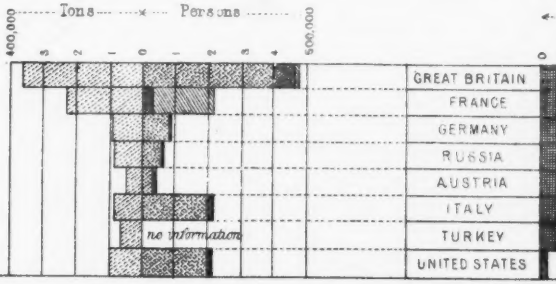
The value of Exports
The value of the Merch
The value of Iron-clad



NAVAL AND MILI

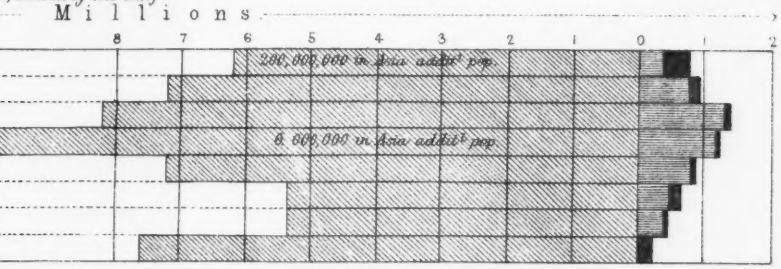
Seamen in War Navy (*Including Marine Troops*)
Reserve do (*The French Seafaring pop. are all enrolled*)
Seafaring Population
Tonnage of Iron-clad Warships

Rank & File only

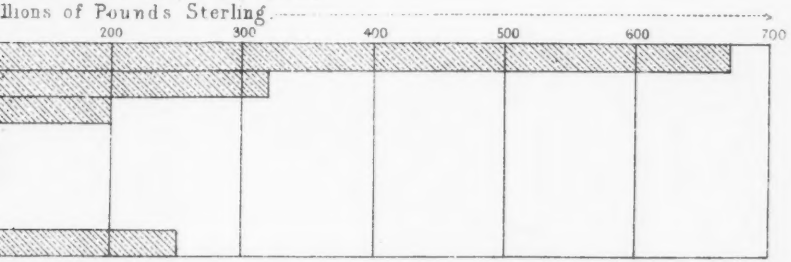


AND THE FLOATING WEALTH OF THE PRINCIPAL NATIONS.

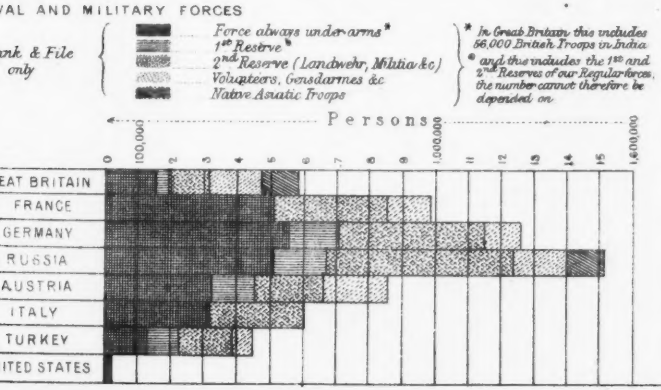
between the ages of 16 and 45 in 1872 (taken at ⅓ the whole population.)
oting, exclusive of Volunteers and Local Forces, and of native Asiatic Troops
, including War Navy.



value of Exports and Imports per Annum
value of the Merchant Shipping at £ 20 per Ton
value of Iron-clad Warships at £ 40 per Ton



VAL AND MILITARY FORCES



J. Jobbins

with such assistance, the small Army of England would have the power of moving round the flanks of all Europe, appearing and disappearing, like the cavalry of the Desert on the flanks of an invading army.

The war policy that Pasley shadowed forth, can now be made a definite system, at the very time that it has become a necessity of our new position. But the alliances that we should make are those of Asiatic powers as well as European, and the flanks along which our invisible forces should move, are those of Asia and Africa, as well as of Europe. With the possessions we now have in the East, and with the alliance and support of Turkey and Persia, we have the power of moving our war forces at will, not only along the whole of the west and south flanks of Europe, but along the whole of the south flank of Asia, and well up the east flank of it.

It is a very remarkable circumstance connected with this increase of our responsibilities in the world, that side by side with that increase, there has grown up a new power of controlling them. The very discoveries in science that have enabled us to extend our interests, have also given us a new means of utilising the ocean, which more than counterbalances their extent; a means that enables us to use to a fuller extent than ever has been done before, the genius of our people, and the resources and geographical position of our island. This new power compels us, for the sake of our vast responsibilities, to have a new war-policy, or at least such a systematic adaptation of our former war-policy as amounts almost to a new one.

An important branch of such a war-policy is the position and condition of our military harbours; and in order to have a just appreciation of their relative importance, it is necessary that we should briefly consider the position of maritime warfare in the present day, and its connection with this new policy I have alluded to.

* The chart of the world shows approximately the floating wealth of Great Britain, both the direction of our sea commerce, and its amount. There is probably always afloat on the ocean, British property greater in value than one year's annual revenue. No other power has so great a portion of its national wealth so open to attack, and no other power imports by sea so large a proportion of the daily food of its people. About one-tenth of the whole exports and imports or about one-sixth of the whole imports of Great Britain, consists of food, coming in approximately equal proportions from Germany, Russia, and America, and the stoppage of which would affect us to a far greater degree and far more quickly than the stoppage of any other commerce to any other nation.

The coloured table shows approximately the resources of the principal nations of the western world. On one side are the powers of the nations for war purposes; on the other side are the interests they have at stake on the sea.

* This chart is a reprint of that accompanying Captain Colomb's paper on the "Distribution of our War Forces" read here in 1869 (see Journal, vol. xiii, p. 37 *et seq.*), with the annual value of the exports and imports of Great Britain, along the lines of traffic therein shown, given in figures. It therefore is only a very general and approximate illustration of the floating wealth of Great Britain.

I have shown the tonnage of vessels on the latter side, because, though a source of wealth, it is a very fluctuating source.

Maritime Warfare.

What is the object of maritime warfare? Certainly not merely the destruction of a hostile fleet, for the complete annihilation of an enemy's naval resources would not of itself necessarily terminate a war; there must be some ulterior object to be gained, of which the fleets are only the means. The defeat of an army generally results at once in the occupation of territory; the defeat of a fleet is only the loss of so many ships and men, unless it opens the road to some other advantage.

There are three distinct ultimate objects for which maritime warfare is undertaken—

1. The defence of our own sea commerce, or the injury of the enemy's.
2. The protection of our own country from invasion.
3. The invasion of the enemy's country.

Of these three objects, the first is purely naval, the two others are more or less combined with military operations.

In former wars in the days of sailing vessels, there was so much uncertainty in movements at sea, it depended so much upon the weather, and the ships themselves, and the skill of the crews, that all naval operations of every kind were necessarily left to be managed as purely professional matters. A Statesman or a General might invent a great war scheme, but directly the expedition left terra firma, it became subject not only to the "everchanging and mysterious sea," but to the technical rule of the seaman. This was of great advantage to the seafaring nations, for no power however mighty upon land, would venture to send afloat an expedition for any object whatever, if there was a probability of its meeting with a powerful fleet of any enemy belonging to those races whose "home is on the deep."

The introduction of steam power into ships has altered maritime warfare considerably in this respect, not only in degree but in kind. The power of moving in any direction at any time with nearly as much certainty as on land, has assimilated to a certain extent naval warfare to land warfare; it has made it possible to have a naval strategy as well as naval tactics, which was all that had hitherto been possible. That is to say, maritime expeditions starting from different points can be made to combine on one point for a particular object with reasonable certainty; at the same time preserving the other advantages of the sea. This property enables a statesman to lay down a plan of operations by sea with nearly as much certainty, and sometimes with more certainty, than he can by land. And the statesman of any great maritime nation who seizes upon this new power of war, and wields it to its complete extent, will perhaps create as great a revolution in war as Frederick the Great did by a new system of tactics.

It is the combination of this propelling power with the large size of vessels that brings the ocean somewhat into the condition of being

merely a means of locomotion, and a very favourable means, instead of being a special element, always doubtful and frequently hostile. And it is these two properties that bring into greater prominence the second and third objects of maritime warfare, as an effective means of terminating a war. The practicability of attacking an enemy from the sea on his own ground has been made so much more a matter of certainty, that all maritime nations are likely henceforth to adopt it more or less, as a part of their general war policy, because it gives to a weak naval power a new and formidable means of threatening and distracting their enemies; and to a strong naval power which has command of the sea, it almost places the balance of peace or war in their hands.

Captain Grivel, of the French Navy, in his interesting work on the future of French Maritime War (1869), points out that the inferior naval Power in a war should avoid sea battles, except under special strategic advantages, and should act mainly by cruisers against the enemy's commerce; whereas the strong naval Power having virtual command of the sea, should attack the enemy's territory and, where possible, its fleet. He compares, what he aptly calls, the "vulnerable surfaces" of different nations from this point of view. The vulnerable surfaces of England are tolerably illustrated in the chart of the world.

Naval operations will henceforth have these advantages over land operations, that they will be more secret, certain, and expeditious, they may cover a large area of action, and the plans can be more easily changed. Before we proceed to apply these ideas to the special question of our strategic harbours, it will simplify the consideration to eliminate two classes of harbours that have distinct requirements, from the strategic harbours proper; these are *coaling stations* and *arsenals*.

Coal.

Coal is almost the key note of the question we are considering to-night, as well as of the larger question of our war-policy. While steam power gives us the advantage in large vessels of being able to move with certainty in any direction, it is coupled with this drawback, that there is a limit to the distance, and up to the present time a short limit. Sailing vessels with all their uncertainty, have this great superiority, that they can go on as long as they can get food for the crew.

The range, as I may call it, of a steam fleet, depends, supposing them to be similar vessels, on the quantity of fuel they can carry, and when a steamer loses her power of steaming, she is worse than a sailing ship. And unless there is a coal depôt at the further end of the voyage, the effective range is really limited to half the distance for which the steamer's coal can carry her; and therefore without that assistance, half the effective time of a steam armament would be lost in going to coal, and half the stowage power would be lost in carrying fuel only to enable them to go and get more fuel.

Hence, if such a war-policy as we have been speaking of is to be carried out in its most effective state, it is indispensable that there should be secure coaling stations in such situations and in such numbers as shall as far as possible reduce such waste of time and

stowage to a minimum. For it is manifest, that if our Navy is so worked up to its full extent, the provision of suitable coaling stations will allow the number of vessels to be considerably reduced below what would be necessary if they had no such assistance to fall back on.

Such coaling stations are to a steam fleet what the depôts of reserve ammunition are to an army. The French Admiral Jurien de la Gravière in his work on "La Marine d'Aujourdhui," (extracts from which have been read at this Institution,) indicates how greatly the want of such depôts is felt in the French Navy, for the realisation of a system of maritime warfare in the present day, for he says, "it is impossible to "undertake such operations if the fleet be not accompanied by a com- "plete train of store and provision ships—and above all for coal. The "transports must be as swift as the squadrons whose operations they "must accompany." Is not this powerful evidence of the advantage which a maritime people which has carefully provided such depôts beforehand, will have over all nations not so fortunate or so prevoyant?

We have some guide as to what I have called the effective range of a modern war steamer, from the high authority of Mr. Reed, late Constructor of the Navy. In his book upon ironclad ships (1869) he gives us the speed of steaming and coal-carrying-power of our principal armoured ships, and of some of the most powerful unarmoured ships of war, of which the following is an extract:—

"Ranges" of Ships of War.

	Coal power.	Total distances to which that coal will carry them.	
		At 12½ knots.	At 11 knots.
	tons.	knots.	knots.
Maximum of unarmoured ships ("Mersey")	850	1550	2320
Maximum of armoured ships ("Monarch")	600	1560	2310

The distances are materially decreased (as Mr. Reed points out), or in other words, the consumption of coal is materially increased, when the speed is increased only slightly at the high rates. But I have taken the maximums, because the power of steaming is on the increase, and because the coal-carrying-power of the great passenger steamers and of our great transports is considerably greater than that of our war ships; and also because under war-pressure, steamers are likely to be forced up to their full powers. Looking at our war-policy in the light I have done, the importance of increasing the range of our war ships is evident.

At present we may take it that a war-steamer's fuel will carry her from Southampton to Gibraltar, but not to Malta; to Halifax, but not to Bermuda; to Cronstadt, but not back again. But we may no

doubt fairly anticipate an increase in the range of war vessels, so that an armoured ship will be able to reach Malta, and a steam transport Alexandria, from Southampton without coaling again. This affords us a sort of measure of the interval at which our coaling stations should be placed along the lines of our ocean traffic over the world. We have now many such coaling stations along these lines, but it will be seen upon consideration of the chart of the world accompanying this paper, in which the lines and amount of traffic are laid down, that additional ones are still required. These coaling stations it must be remembered are required for other war objects besides the protection of our maritime commerce. The question of their provision in foreign seas is also connected with the subject of making coal a contraband of war. As long as we possess the main supply in our own hands of this indispensable war-material, it is manifestly to our advantage that we should keep up a stock of it at all these necessary points, and that it should be contraband: as in such case the absence of such provision by an enemy would cripple all their maritime operations, and eventually stop them altogether. But my business now is not so much with regard to these outlying ports, as to what is required round the coast of Great Britain.

When we come to the coasts of Great Britain, the coaling stations must be much closer together. The war-ships defending a coast line must be so disposed as to be reasonably certain of being able to attack the enemy's invading force before they have completed the disembarkation; and a disembarkation from the time of the first appearance of the vessels on the horizon is, in these days of powerful steam vessels, a question of hours not of days; and the single guardships of the coast should be so stationed as to be within a few hours' reach of such parts as are likely to be subject to the visits of the enemy's cruisers. The requirements in a coaling station for war vessels are, first and chiefly, smooth water; secondly, facilities for coaling both from wharves and by barges or vessels. The filling up of a large war steamer with coal takes 10 or 12 hours when done in the most expeditious manner. Thirdly, a coaling station should be fortified against an attack by sea, otherwise you will be providing a depôt for your enemy; and not only against an attack by day, but against any desperate attempt at night to burn the stock of coal by special vessels prepared for the express purpose. The coaling places for large vessels on our coasts are not so many as might be expected; and few of them meet the above requirements.

Without going into details of the different harbours, there are about 20 places round the coasts of Great Britain at which the largest war vessels could lie and coal, and there are only four of these that fully meet all of the above requirements; moreover, of these, three are near together on the south coast. Of the others, they are either tidal or difficult of access, or are not protected by land works, and only at Portland is there any special arrangement for coaling. At three or four of the others there is only a coaling hulk; whilst for a distance of more than 150 miles on the part of the coast most exposed to attack from the Continent, there is no provision for coaling of any kind. A

guard-ship therefore would have to be absent from her station at this part for probably 30 hours for the purpose of coaling. The completion of the harbour at Dover would remedy this serious defect, and would provide the remedy at the point most favourable for the position of the guard-ships.

The fact is, our ships have outgrown our harbours. It would be waste of money, with the prospect of the increased size of vessels, to go on endeavouring to improve matters in harbours, only available to certain of our war vessels. Evidently the more desirable course would be, gradually to complete those places, which are available for our largest vessels, until they are provided with all the above requirements. The actual arrangements for shipping the coal may be left to the ingenuity of our engineers to supply when wanted; but what cannot be done at the time are the land defences for securing the coal when there, and without which a certain portion of our fleet would be employed acting as sentries over coal-hulks round the coast. Falmouth may be taken as a specimen; a fair deep water harbour in an admirable position, but so far as its defences are concerned, pretty much in the condition in which it was left by Henry the Eighth.

I have not alluded to the supply of coal to war-vessels in roadsteads or the open sea, because I consider such a method to be exceptional, an expedient only to be adopted in war time to supplement the permanent depôts.

I did not also think it necessary to include in the list of requirements that there should be a supply of coal at each station. But I mention it, because in time of peace it is a subject that gives rise to difficulties, not being felt to be so important. Considering its vital necessity in war, it is of great importance to establish some system of securing our war depôts of coal over the world, as shall obviate those difficulties, as far as possible.

Naval Arsenals.

The next accessory on land for the prosecution of naval enterprises that we will consider, is that of arsenals, or, as we more commonly call them, dockyards. If the coaling depôts are like the ammunition trains of an army, the arsenals are like the grand depôts of stores which an army requires at some secure point of its main base of operations. They are indeed more important than these, because in every fleet there will be some ships after every engagement, and, indeed, after every heavy gale, that will require such repairs as can only be effected in a properly equipped dockyard. The absence of one within reasonable distance might deprive a fleet for the whole of a campaign, of some of the disabled ships in it, and perhaps cause their total loss.

There should be within the limits of the station of each separate fleet, one such arsenal, in which armour-plates can be removed and replaced, steam machinery repaired, guns and carriages refitted, and the bottoms of vessels examined and cleaned.

There is this difference between a coaling station and an arsenal, as regards position, that the former should be as easy of access as prac-

ticable, whereas one of the most important points about the latter is, that it should be as secure as possible from all attacks by land or sea; because, if the enemy could seize or destroy it, its loss to you would only be exceeded by the great gain to the enemy, if they could get the use of it. Probably the operations of a great maritime war will now turn very much on the securing of such refitting harbours in favourable positions in the sea of war. They are not so much the strategic camps of the ocean as the objective centres of offence and defence.

Great Britain has several such centres in the different seas where her interests lie, but there are some seas in the East where others are still required, where our commerce and other interests are very large, and where the war vessels protecting them would, in case of certain repairs being required, have to go some thousands of miles, and be absent many weeks, and perhaps months, before they could be effected. When we come to our own shores, we find several such arsenals, more, indeed, than are perhaps now required for a steam navy in the positions they are in. If we could now determine afresh the positions of our dockyards under the new light of steam warfare, and of the present condition of the continent of Europe, we should perhaps be inclined to have one on the north-east coast and one on the north-west coast, instead of Plymouth and Milford Haven. Of our five imperial dockyards, three, Chatham, Milford, and Cork, are reasonably secure, by their natural position, as well as by their fortifications, from attack by sea; Plymouth and Portsmouth depend, in this respect, mainly upon their artificial defences. Moreover the outer harbour of Plymouth is, like Cherbourg, very open to audacious assault; the outer harbour of Portsmouth, through a fine, strategical anchorage, from its having two entrances at opposite ends, is not a satisfactory one for large ironclads, on account of the exposure to sea, winds, and tides, and the inner harbour has the very serious defect of being tidal.

These places are, however, legacies that we have inherited from other days, and which we shall probably have to make the best of to the end of our history; and it must be borne in mind, that they are extremely valuable for other purposes than arsenals; as places of shelter for our merchant vessels both in times of peace and war, they have a commercial as well as a military value. In the meantime there are mercantile yards on the north coasts available for the repair of all but our first-rate war ships, such as on the Humber and the Tyne, on the north-east coast, and on the Mersey and the Clyde, on the north-west coast. The deepening of the waters in these rivers and the defence of them, will some day, perhaps, become a question for the consideration of the Admiralty, and will probably have a bearing on the subject of a second great military arsenal for Great Britain.

On the subject of artificial defences of naval arsenals, I will take the opportunity of saying,—and I have little doubt that my brother military engineers will concur with me,—that we engineers have never supposed that fortifications are a universal panacea against an enemy, to the exclusion of other means of defence. Fortifications are the means of enabling you to set free so many more men and ships for that

offensive warfare which is the *only true defence*. If all our naval arsenals were so placed and fortified that we should feel them perfectly secure in the hands of our Militia and Volunteers, then the whole of the regular forces of Army and Navy, thus freed from restriction, would be available to effect greater injury on the enemy in other ways, and thus bring the war to a quicker termination. The vast number of vessels that will be required to protect the interests of England on the sea in war time, will probably astonish those who trust entirely to ships for our defence.

Strategic Harbours.

I now come to what is the important question of this paper, and indeed, of maritime warfare, as far as accessories on land are concerned, for it involves the subject of the general system of conducting maritime war in the present day. I feel, therefore, that I am treading on delicate ground, and am opening myself to professional criticism. As, however, the opinions of Naval Officers themselves appear to be uncertain on this point, there is more excuse for a soldier venturing to express his.

This important question is that of the best position for those anchorages and harbours of refuge, which would be used from time to time by a fleet operating in any sea, or by a disabled or overpowered squadron, for temporary shelter and refitting, and which, therefore, being the pivots of their movements, may be more properly called strategic harbours, in contradistinction to coaling places only, and to arsenals only. A strategic harbour ought to be easy of access, large enough to hold at least a squadron—some in special positions should be capable of containing two or three squadrons—and it should be fortified towards the sea.

It will be convenient to consider them in respect to the three objects, which I have supposed to be the ulterior intentions of all maritime war. 1. The attack and defence of sea commerce. 2. The defence of a country from invasion. 3. The invasion of a country.

1st. *The Attack and Defence of Sea Commerce.*—Considering the command we have of the sea, and the extent of our sea commerce, we must expect that the first idea of any power at war with Great Britain will be to get their war-fleet out into the open ocean, to attack that commerce. The extraordinary effect on the sea commerce of the Northern States of America, by one or two improvised cruizers of the Southern States, and at a time when the North had shut up the war vessels of the South in their posts, has been more than once pointed out in this Institution. The question therefore arises whether such blockading of the enemy's war vessels is practicable in these days, and even if practicable, whether it is likely to be effectual for the purpose. As far as I can ascertain the opinions of Naval Officers who have considered this point, it appears to be extremely doubtful whether an effective blockade can be maintained in the face of the large, swift, steam-vessels of the present day. Blockade-running has become in these days of steam, more of a regular business than it was in the days of sailing vessels. The

power of choosing the time and direction for the escape of war vessels blockaded; the time lost in turning large ironclads to pursue a flying steamer; the probability of some of the blockading vessels being deficient in coal, or absent coaling; and the loss of strength in parcelling out our naval power among a large number of ports widely apart, are the chief reasons against continuing the system of blockading war harbours.

Steam-power is in favour of the assailants, and in this case the escaping party is the assailant.

There might be wars in which such a system would be effective. For instance, if we were at war with only the two great Powers of Northern Europe; if we had possession of the Dardanelles or Bosphorus, and of Copenhagen, that would go far to checkmate the naval power of our adversaries. But although this shows the importance of preserving a close alliance with both Powers that possess harbours in such important positions, it would not shut up the naval power of North Germany. And again, if we were at war with the Great Powers of Southern Europe, there would be no possibility of so easily excluding them from the sea of operations.

Therefore it appears probable that, on the whole, for this important branch of naval warfare, fleets will in future work on, what we should call on land, interior lines; and that the most useful positions for strategic harbours will be just in rear of those lines, to continue the military simile. The swiftest vessels would be watching the enemy's movements, like the outposts of an army; squadrons would be detached to cruise in certain lines for the protection of the sea-traffic against single cruisers, with instructions to keep up frequent communication with the main body of the fleet, which would be stationed in some position most favourable for moving in the directions in which the enemy's main fleet might operate.

The best strategic lines for the defence of a sea, are in some respects the reverse of those favourable on land for covering a tract of country. On land a convex line is favourable to the defenders, because they can move by the interior lines, shorter than the enemies round the circumference; but at sea, with the land behind you, preventing your moving by those interior lines, the most favourable line for defensive strategy would be a concave one, and the best position for the main body would be near the centre of the curve.

Again, it seems probable that indefinite cruising by independent vessels will not be carried to so great an extent as has been the case heretofore. A cruiser must be a very fast vessel, and must always keep a reserve of coal on board to carry her to a friendly port. Such ports, where she can obtain a supply of fuel, though it is not a contraband of war, will, in the case of any country at war with Great Britain, be few in number; hence the range and the area of operation of such a vessel will be limited; and therefore cruisers will probably act in the shortest lines from their harbours of refuge that will effect their object.

The defence of sea-commerce will probably be conducted on similar ideas. Fast vessels will patrol along certain lines, from one friendly

port to another, if possible, across the line of traffic, and so as to cover as much of it as practicable. Precise courses and precise points of rendezvous would be laid down for these vessels, in order to keep as constant a watch as possible over the line patrolled. The number of vessels employed on this duty would depend on the length of line to be patrolled; or conversely, the lines of patrol adopted would depend on the number of vessels available. This would, I conceive, be a more effective and economical mode of protecting the traffic, than by attempting to follow the enemy's cruisers in the open sea, as such a plan would require more vessels than even Great Britain would be prepared to furnish. Any arrangements for the supply of coal in the open sea would, of course, enable the lines of patrol to be lengthened; and the means of speedily communicating intelligence at sea would become a matter of great importance, as telegraph cables must not be depended on in war time.

It must also be considered that in war time, only fast merchant steamers would be employed in commerce.

With regard to the disposition of the main body of a fleet, I presume that the object of the *inferior* fleet would be to concentrate at some time and place unknown to the superior fleet, so as to meet it, if possible, in greater force, and that for this purpose, a great deal of manœuvring and feints would be employed, to divert the attention and separate the forces of the superior fleet. The concentration would take place at sea and not in harbour, otherwise there would be the risk of the superior fleet shutting up the chief part of the enemy's naval forces, and it would then be worth while to institute such a blockade of that one harbour as would do it effectually.

The object of the *superior* fleet would be to prevent, if possible, this concentration, and to overpower the inferior fleet in detail; and it would therefore cruise in such a course as would enable it to keep up its intelligence along the probable line of the enemy's operations, and to intervene before the junction. But this main body must have coal as well as the cruisers, and the number of vessels required to form an effective fleet on such service will be in some proportion to the distance of the coaling station from its line of operations.

The French Admiral above quoted seems to have had some such idea as this in his mind, when he says, in the same work, "What our (the "French) Navy has done in the last 50 years is nothing to what it will "have to do in the event of a naval war. I have very often sketched "in mind the constitution of a fleet which could at any moment unite "its scattered fragments, and concentrate formidable masses on two "or three previously chosen points. . . . . I revived on a "larger scale the plan of 1805, convinced that the fleet which can "most promptly concentrate, ought to be able to keep for several months "the advantage gained in the first few days." This is naval strategy. Not dispersing your fleet in the attempt to prevent the enemy's ships from leaving their harbours at all, but so disposing it as to be able to concentrate and meet the enemy's fleet in superior numbers, before he has accomplished his object. This is what steam has rendered possible.

What, then, should be the disposition of our fleet, and what strategic harbours are suitable for the protection of our commerce in the neighbourhood of our coasts? The line of British cruisers watching the south-west approaches to the British coasts would probably extend from Cape Clear to Land's End and Ushant; the position for a fleet supporting them would be probably at Plymouth. We have fortified strategic harbours at Cork, Milford, Plymouth. As *time* is the essence of naval operations now, Falmouth would be preferable to either of the others as the place for the main fleet, being in an advanced and central position, from which the Admiral would most readily obtain his information from his fast steaming scouts; but Falmouth is not large enough for such a purpose, and not fortified. Therefore Plymouth, being now a commodious and accessible harbour for large war ships, would probably be the head-quarters as far as the protection of this part of the coast is concerned; the other harbours would be the places of refuge and supply for the cruisers.

We have two fortified harbours further up the English Channel, Portland and Alderney, which, being only 60 miles apart, are favourably placed for the support of cruisers, which would thereby effect the double object of closing the Channel at that line, and of separating Cherbourg from the other French war ports. It may, however, be doubted whether it would have been now worth while to construct a harbour at Alderney for these objects; as the harbour exists, and is of that value to us, and would be of very great value to an enemy, it is desirable to hold and maintain it. During the late war between France and Prussia, if the French had possessed a harbour off the coast of North Germany, they would doubtless have carried out their idea of invading the Prussian territories at that point: Alderney, in possession of Prussia, would be just such a harbour as regards the invasion of France or England.

But when we come to the other ends of the two British channels we are not so well provided with fortified strategic harbours. In the North Sea the line of cruisers would probably extend from the Frith of Forth to Heligoland, with outliers as far as Aberdeen: and the position for a fleet supporting them would probably be Yarmouth Roads. We have two deep-water rivers on this coast, the Thames and the Humber, but the safe anchorages in them are not so easily accessible as should be the case in strategic harbours; and in neither of them are they fortified. Harwich Harbour, though fortified, on account of its depth of water and difficulty of access, cannot be considered as available for a large war fleet. Then there are three anchorages, the Downs, Yarmouth Roads, and the Frith of Forth, all in favourable positions, but roadsteads only, not harbours, and imperfectly defended from the shore; and therefore suitable only for fleets of such size as are not likely to be attacked by a superior force. There are no fortified harbours north of the Humber suitable for the refuge of cruisers. There therefore appears to be required on the north-east coast, both for coaling and for the refuge of disabled or overpowered squadrons, a smooth-water harbour, easily accessible, and well defended from the shore.

At the north end of St. George's Channel a line of cruisers from

Lough Foyle to the Mull of Cantyre would close it, and would be supported at each end by the excellent harbours of Lough Foyle and the Frith of Clyde, which only require fortifying to make them effective for this purpose.

But we must consider what would be the ultimate object of the supposed inferior fleet in endeavouring to surprise the superior fleet and defeat it in detail. This might be either to leave the enemy's commerce more exposed to attack, or to cover a disembarcation in the enemy's territory. It is the latter of these considerations which I think would determine the position of the main body of the home fleet of Great Britain. If the home fleet was divided among the different small seas surrounding Great Britain for the protection of our commerce, it would be liable to be attacked in detail by the combined fleets of our enemies.

However important the protection of our commerce is, it is more important to protect London, and until London is otherwise made secure, it will probably be found indispensable to keep the main body of the home fleet massed in the Channel.

We cannot expect, with the demands of the other parts of our empire, to be able always to keep such a proportion of fleet round our own shores, as will be superior to any probable combination of enemies' fleets. It is, therefore, important that it should be so disposed as to be capable of quick concentration, and of moving to either sea. If London is ever made secure against capture by other means, it might be practicable and advantageous to employ the whole of the home fleet elsewhere.

Portsmouth is in a favourable position in this respect, but considering the increasing power of the two great Northern countries and their proximity to our shores, Portsmouth appears to be rather too far from the east coast. This again points to Dover as a suitable position for a strategic harbour. If completed it would fulfil, in all respects, the requirements of one, and it is situated in one of those positions marked out by nature for the command of sea traffic. The Straits of Dover are the gates dividing the sea traffic of Northern and Southern Europe. The Channel fleet divided between Dover and Portsmouth, would be in good strategic positions for combining and acting, either in the North Sea or St. George's Channel.

2nd. *For the Defence of Great Britain against Invasion.*—I am not going to discuss the possibility, or even probability, of such an event ever occurring as a determined invasion of England; that would lead me far away from my present subject, and re-open a question already well settled in this Institution. Our object to-day is to consider what accessories on land in the way of harbours are desirable to enable the smallest naval force spread round our coasts to render such an undertaking a desperate adventure, leaving the mass of the fleet still available for offensive warfare. And I will assume that some time during the course of a war our enemies see an opportunity of distracting the attention and dividing the forces of this country, by making deliberate preparations for invading it on a large scale. And we must bear in mind that the preparations and the threat would be sufficient of them-

selves to rouse the people of England to make as complete arrangements for defence as would be required if the threat were fully carried out.

The main object of any such expedition would be the capture of London; no foreign Power would undertake so tremendous an adventure except for such a prize. But in addition to the main attack, there would be other attempts at landing in distant parts of the kingdom for the express purpose of dividing the attention of the defenders: indeed such subordinate expeditions would probably be undertaken, whether the grand enterprise came to a head or not. Any landings, however, effected at such a distance from the capital as would allow time for the massing of the defending forces between it and them, would not have the capture of London for their object, but either the levying of contributions from some of our wealthy provincial towns, or the fomenting of insurrection.

The levying of contributions from undefended towns by war-ships we are sometimes inclined to consider as a relict of barbarous warfare that will soon be exploded from the international code. But besides the fact that one great maritime Power has not yet joined the league against privateering, we must not expect that any Power will forego the opportunity, if it has the power, of inflicting injury on its enemies by making requisitions by sea as well as by land. Therefore it is necessary for us, who have so much to lose in that way, to make the rivers and harbours near our great mercantile towns as secure as practicable against such subordinate expeditions. We have several such places as at the present moment offer a very tempting bait to a small force. There is little to oppose the assault, and an extraordinarily rich booty to be gained. For the rest of the coasts of Great Britain and Ireland, all that appears necessary is to provide some land batteries at such harbours as are most suitable for a landing.

But for those parts of the south and east coasts which are so near to the metropolis, and also so near to the continent of Europe, as to invite the attempt of landing a large force for its capture, the defences should be much more multiplied. Every small harbour should be protected as far as practicable, and at every anchorage and landing place there should be batteries. The special vessels for guarding the coasts and the coasting trade, which would doubtless be stationed all round Great Britain in such times, should be multiplied on these parts of the coast; every small harbour would be a port of refuge and supply for those vessels; and the land defences would be a support and protection to them, as well as to the vessels employed in the coasting trade, which would have to take refuge in the harbours and anchorages. Where land defences can be applied in such situations, it must be recollected that they not only enable you to reduce the number of sailors and ships required for the defence of our coasts, but they supplement them at a very much cheaper rate. For the same expense for which one gun can be mounted and kept effective in an armour-plated vessel, about ten guns can be mounted in the strongest manner and kept effective on shore.

Every additional defence of this kind tends to put the coasts in the

position of the bank of a river which the enemy cannot get at. It enables single vessels of war or commerce to pass with impunity along the coasts almost in presence of the enemy. It is difficult to define a distance apart for such defences: the minimum distance is of course the effective range of large guns; the maximum distance should depend on the probable number of the enemies' cruisers and on their distance from a coaling station. And it must be remembered that every harbour left undefended is not only a loss to your own vessels, but a gain to the enemy. Captain Grivel alludes feelingly to the undefended French harbours.

It is remarkable that Dover is situated at about the centre of that part of the coast, which I have considered the most liable to invasion; therefore a war fleet stationed there for other war purposes would be in the most favourable position for acting against any force coming from any direction with the serious intention of endeavouring to land and capture London.

3rd. *The Invasion of an Enemy's Country.*—There is one more branch of maritime warfare in the prosecution of which the assistance of harbours are indispensable, and that is the counterpart of the last one, namely, the attack of an enemy's territories; and this is the branch which I have considered as likely to be of more importance to a maritime Power like Great Britain than it has hitherto been. I have supposed it probable that a foreign Power at war with us would seek to divide our forces, both naval and military, by threatening an invasion of our territory in different parts: this might be the British Isles or one of our colonies; wherever it was, it would have the effect of obliging us to detach men and vessels for its defence. But in the present condition of the naval forces of the world, there is no foreign Power which could undertake any such expedition on a large scale to any considerable distance on the ocean with a good prospect of success. To have a fair prospect of succeeding under these conditions the country must have a certain amount of command on the ocean, a powerful steam transport fleet, and coaling stations and harbours, near the coasts to be invaded. Great Britain is at present the one Power which possesses these requisites to any degree, and she possesses them, or could possess them, to a degree so much beyond any other Power, that it might become an exceptional war-power in her hands.

The general idea of making the war-policy of Great Britain one greatly of combined naval and military operations is not a new one. Sir Charles Pasley wrote his celebrated book on the war-policy of this country mainly to support that idea. He wrote in the midst of the excitement of the great European war of 1808, when Napoleon was wielding enormous armies on the continent of Europe, and when movement by sea were retarded by the cramped and uncertain means of small sailing ships. But that able and energetic man was so impressed, even then, with the advantages to England of such a policy, that he actually contemplated having 150,000 men ready in England to be transported to any coast in Europe. How much more advantageous would such a policy be to us now, when our colonial interests are so very much larger, and when the use of steam power, and especially of

large swift steam-vessels, opens the door of the sea to us. From henceforth we may expect, to use the words of Captain Hoseason, R.N., in his pamphlet on the Transport of our Army, that "*England's base of operations is the ocean.*" Here I wish to take the opportunity of acknowledging the information and benefit I have received from that Officer's various writings on these subjects. And we may expect that it will be acknowledged before long, that one of the surest guarantees of peace will be the knowledge that Great Britain has deliberately and carefully prepared her war forces, so that a complete little army can be embarked in a few days' notice, in large transports capable of conveying them with certainty to any part of the world.

This would not be the adoption of a new policy, but only the reduction to a determinate system, of a scheme of operations that has hitherto been left to be settled by the chance opinions of the day, and to be carried out by such means, in men, stores, and transports, as could be hastily got together for the particular purpose in hand. It is one which quite belongs to the traditions of our own race, and indeed has been the policy of all the great maritime nations recorded in history. As long as they were powerful, their plan of war was to invade the enemy's country from the sea; when they ceased to be so venturesome, it was because they were ceasing to be so powerful; and considering the vessels of the time, some of these expeditions were as large and as distant as the transport of an Army across the Atlantic would be to us. In our own day the French have deliberately utilised their war fleet for similar purposes, to their great advantage in more than one late war. During the last war between France and Prussia, the possibility of the landing of a French force on the northern coasts of Germany kept several corps of the Prussian forces lying idle quite away from the scene of the great operations.

To Great Britain, in its present circumstances, it appears to me that a war policy based on this idea is not only advantageous, but a necessity. The preservation of our connection with India makes the alliance of Turkey a matter of importance to us: for the security of its western frontier the alliance of Persia would be most valuable; and if either of these two Powers was threatened by our enemies, we could support them in the most effective manner by landing in their territories a a force large enough, when combined with their own troops, to form an effective Army, and so get the advantage of having their country as a base of operations; while at the same time we could distract and harass the enemy by appearing on his own coasts, with a small force, such as could be easily disembarked and re-embarked, and moved from one point to another, quicker than his troops could move by land. But such a system to be really effective, must not be left to be carried out by such small contingents of troops as happen to be available at the moment in England, and embarked in such hired transports as can be found in the market, and supplied with such stores as happen to be left after the last reduction of the Estimates. We have happily got already some way beyond that haphazard way of drifting into war; but we have not quite arrived at the conviction, that the wisest and most economical and pacific course is to frame our whole war

forces on it as a national system. To organise some part of our Navy for the express purpose, and to organise some part of our Army for the express purpose of transport in ships, so that the sailor and the soldier will feel themselves to be comrades in the same expedition.

An important part of such organization must be the means of quickly embarking large bodies of men and stores at some favourable points on our coast; and this is where it concerns the subject we have now under discussion. It is remarkable, considering how often we have found ourselves compelled to send away a little force to foreign wars, that there are no arrangements at any of our harbours expressly for the purpose. The transports lie alongside the dockyards or arsenals as they can, and in times of war-pressure, those places are absolutely choked with work; and the chief port of embarcation, Portsmouth, being a tidal harbour, is liable to delays, and so to greater pressure. The harbour of Dover, if completed, would be a most convenient place for this purpose, because the embarcation could be effected in smooth water at all times of tide, and in several vessels at once; and it is accessible by three independent lines of railway from our great military and naval centres of Woolwich, Aldershot, and Portsmouth.

Summary.

I have not herein proposed any new project for the defence of the empire, but only the completion into a more perfect system, of that policy which has been already begun.

It may be described generally, as the effecting of the security of Great Britain itself by local means, and the systematic and combined organisation of the regular Army and Navy for offensive action against the enemy.

This will, perhaps, be thought to be a more aggressive policy than that which this country has generally followed. I don't think it is likely that Great Britain will ever be accused of having an aggressive policy; her vitality depends so much on peace, that her greatest enemies must acknowledge that she has nothing to gain by war and much to lose. Hence the best war-policy for her, is that which will soonest bring peace—peace without injury.

I maintain that the policy herein advocated is not only the most effective to that end, but is the only one by which Great Britain can expect to be able to terminate a war, except to her own loss. The multiplying of sentinels by sea or by land round our coasts, the escorting of our own sea-traffic, or the stopping of that of the enemy, will not of themselves bring a war to a conclusion satisfactory to Great Britain, because she herself is the only Power that would be vitally affected by a war system of that nature.

But there is the other argument in favour of its adoption by England, that we are the only nation that can use it effectually. Our coal and iron, our adventurous seafaring habits, our insular position, together constitute a special power in the hands of this country, so remarkable at this epoch of our history, that it would almost seem to have arrived at its perfection for the express purpose, and at the express time required for the security of our interests.

I might also advocate it as a necessity, on the higher ground of our responsibilities to those nations placed under our protection; but as that argument would lead me altogether beyond my subject, I will content myself with a final reason in its favour, of a more homely character, namely, that it would be economical. The combination of our war forces by land and sea into one system would, no doubt, lead to our having a War Department in reality as well as in name, and could, therefore, hardly fail to produce economy, not only by direct reduction of certain expenses now required in duplicate, but by the greater efficiency and more determinate action of a single controlling power over our war policy. It would realise the idea of one of the wisest soldiers of our day, Sir Henry Harness, of the Royal Engineers, that, "The War Minister of England should be strategist of the empire, "and the units he should deal with, are Fleets and Armies."

Lieut.-Colonel CROSSMAN, R.E.: If you will allow me I should like to speak, as having had some conversation with Captain Hoseason I find that he has some views in the matter which he would rather bring forward after he has heard what I wish to say. General Collinson has referred to a harbour on the north-east coast of England. Now in making remarks upon a harbour on the north-east coast one must not only go into a strategical subject entirely, but must also show the necessity for making a harbour there, independently of the strategical reasons for so doing. We are all aware that the trade on the north-east coast is as important, if not more so, than that upon the rest of the coast of England; and many of the ships trading on that coast, too deeply laden or flying light, are not so well found as the large sea-going ships that go down the channel and have large harbours prepared for them. The coast too is nearly iron-bound: from the Fern Islands to Whitby it is deeply embayed, and beyond that it is almost a straight line. On the whole of that coast, from the Humber to the Frith of Forth, there is not a single harbour to which ships can run for shelter in a gale of wind. Much has been done at the Tyne, the Wear, and at Hartlepool to improve the docks and approaches to them, and too much cannot be said of the public spirit evinced by the local authorities of those large and important ports in what they have done and the large sums they have expended; and even smaller places like Berwick have been doing the same thing. All these harbours, however, are tidal, and their entrances are barred at low water. A glance at the wreck-chart shows the vast number of wrecks that have occurred along that coast; and when it is stated that in three years, from 1854 to 1857, 109 lives were lost, and property to the amount of £110,000, was sacrificed in *two* gales only on that coast, what more need be said to show the necessity, in a commercial and philanthropic point of view, for the necessity for some port to which vessels might run at all times of tide. Lord Claud Hamilton has on several occasions brought this matter before the House of Commons; and reading his speeches, and also the Reports of Commissions that have been held, and of Committees of the House of Commons, it is a wonder to this day why the question has been shelved so long. Objections have been raised—it is very curious to say, principally by shipowners themselves—against the establishment of any harbours of refuge on that coast at all, on the principle, they say, that the masters of their vessels would rather run into the ports than keep the sea, and also that their ships are so well found that there is no necessity for the harbours of refuge at all. I think Mr. Plimsoll has shown that that argument will hardly hold ground. There is no doubt the ships owned by the large shipowners of England are as well found as ships can possibly be, but even the best found ship is liable to accidents, and requires sometimes to run for shelter; and one might as well say that no hospitals should be provided for accidents, because a man ought to take so much care of himself that he should not get his leg broken by a cab running over him. It is no use entering into the different claims of various localities that have been recommended by different people, whether Redcar, Hartlepool, or Filey Bay is the best position. Filey Bay has most evidence in favour of its capabilities. It was the

spot recommended by the Royal Commission of 1859; and when it is known that Sir James Hope was the Chairman of that Commission, and that two naval Officers, two Officers of Engineers, Sir John Coode, C.E., and Mr. Lindsay, the shipowner, were the people who recommended it, there can be but little doubt that it is the best place that could be chosen. In fact, to sum up in the words of Sir John Coode, it would have not less than 200 acres having 5 fathoms depth of water and upwards, at low spring tides, sheltered from every gale, and fit for the reception of the largest class of ships in the Navy; 403 acres with 2½ fathoms of water, that will hold all colliers and coasters; and besides, there is a considerable amount of space sheltered from all prevailing gales. I may add that a model of that harbour is exhibited at South Kensington showing the exact space that will be available. There is ample depth of water for vessels of any size up to the largest class of vessels in Her Majesty's Navy; holding ground which is rarely equalled and cannot be surpassed; entire freedom from all banks and shoals; absence from all tendency to deposit; an abundant supply of fresh water of excellent quality; and stone of a suitable quality for a breakwater in the cliffs immediately adjoining. And with regard to its position for offensive and defensive purposes, a glance at the map shows how admirably situated it is with reference to any invading force issuing from the Elbe or from the Baltic. All that has been said with reference to the advantages of Dover, Portsmouth, and Plymouth applies equally to Filey. I do not say that as having any more interest in it than in any other place on the north-east coast, but it is the place recommended by the Commission. It is on the most salient point along the whole coast. They say that harbours of refuge perhaps are better on a bight than on a salient point; still this has the advantage of both. It is six miles from Flamborough Head, which is the point of departure for all ships going to the Baltic, and it is admirably situated as a place from which a fleet stationed there would flank both the coast north and south from the Forth to the Humber. It is about half way between the Frith of Forth and the Thames. There is nothing from Yarmouth Downs or from the Humber to the Frith of Forth where any fleet could take refuge; and I think strategically this is a most important point, and one that ought to be carefully considered. Now Government are going to expend, as I understand, a large sum of money in making a harbour of refuge at Dover. The south coast have Portsmouth, Plymouth, and the Downs, and I think certainly the north-east coast has a prior claim, not only commercially and philanthropically, but also economically. One word about the cost of a harbour at Filey Bay. The Report of Sir John Coode states that it could be done for £860,000. I believe that it might be done for much less. Of course it may be rather presumptuous in me to say so, but I may mention that it is exactly the sort of work upon which convicts can be most advantageously employed. Any one who has seen the work that has been done by convicts at Portland in making the Breakwater and excavating those immense quarries which have formed the ditches of that impregnable fortress at the Verne, will know that the work of excavating and throwing the stone, as it were, into the water, is work exactly suited for them. The stone from the point at Filey is particularly suitable for the construction of that breakwater, and I consider that that work is much more appropriate for the employment of convicts than building prisons or raising fortifications. Both of these require rather skilled labour, and although that skilled labour may be obtained to some degree amongst prisoners, still I think the main element of the working power of convicts is brute force, and that brute force can be more advantageously employed in excavating stone and throwing it into the sea to make that breakwater which I consider of so much use. Doubts have been thrown upon the comparative economy of convict and free labour, but these doubts have arisen principally from civil engineers who have found themselves hampered in fact by the restrictions necessary for discipline amongst the convicts, and also from the difficulty of combining contractor's work with free labour. But now that there is an Engineer Officer of great experience at the head of the convict establishment, I see no reason for the employment of any civil element at all. Let the Government hand the work over to Colonel Du Cane, and give him such assistance from his own corps as he might require to work under him, and I feel convinced that instead of £800,000, little more than half that

sum will be required. Of course that is a matter we cannot go into. I think commercially, philanthropically, and from a strategical point of view, a harbour of refuge on the north-east coast is one that ought to be taken in hand at once, certainly before the one at Dover that the Government intends to take in hand. Filey is close to the districts where we get our coal and iron; it has railway communication at hand; and if that tactical station which I hear is going to be built in the north was placed in connection with it, you would have that combination of naval and military defence for the north part of our country which is most desirable.

Captain HOSEASON, R.N.: I was not prepared when Colonel Crossman rose, to make any speech relative to the harbour at Dover, except in relation to the paper before us; but as he has shown the merits of Filey, I am bound in duty to show the merits of my own child. I did not expect to succeed with the Government by the weight of any such arguments as Colonel Crossman has adduced in support of his own scheme. When I pressed my views on the Government, I stated the fact that Dover was a town with 26,000 inhabitants; that it had a harbour there of 27 acres; that two railway companies had expended £36,000,000 on their lines to Dover; that Government had invested millions of money on the fortifications, and that there was already barrack accommodation for 10,000 men. I argued that the port at Dover was in connection with many of our great arsenals, and that a minimum sum of money was necessary to make the whole perfect. I pointed out to the Government that they had already invested £750,000 on the pier, and that in consequence of not making a harbour, but only a pier, they lost the interest on the capital invested, calculating the money already expended at compound interest on the pier at £1,130,000, they had thus practically lost in interest £380,000 through not making a harbour, and that that would go on in perpetuity, unless they enclosed the bay and so realised an income to the port of Dover. I proved clearly before the Government that the passengers alone between Ostend and Calais would give £11,000 a year at a shilling a head, the sum named by Mr. Lowe in the Bill now before Parliament, and that sum is equal, within £5,000 a year, to the whole revenues of the Harbour Board at the present moment. Much as I should wish to see a harbour at Filey at a future day, I agreed with Mr. Chichester Fortescue in his reply to Lord Claud Hamilton, when he said that he would create no new port, unless it could be proved that it was essentially necessary for offensive and defensive warfare. Therefore the time to think about Filey will be when we see any of our northern friends developing themselves so greatly that we may begin to fear them as a maritime nation. Till then we are to look to other quarters as a means of defence. I am happy to say, the Commanding Engineer who was at the port of Dover, whom I consulted on this measure, was my gallant friend who has just sat down. It was he who gave me support—he who urged me to write the letters in the daily journals—he who pressed me to publish the pamphlets which I laid before the Government; it was he who supplied me with all the drawings necessary to enable me to do so, and if success has attended my efforts, it is mainly due to the able assistance I received at his hands. I can further say, that the gentleman who was to have sat in the Chair which you, Sir, now occupy, Colonel Jervois, has been from first to last the warmest advocate of the complete utilization of Dover. It was he who declared that Dover would be to this country what Metz, Strasbourg, Mayence, Cologne, and other forts are to Germany; I might say more, for none of those garrisons have such a flow of commerce to protect, as my friend has shown here. It is for the protection of this great commerce coming from England down the Channel that the harbour of Dover will be so essential. I do not advocate the port of Dover for defensive warfare alone, but for offensive warfare, and with your permission I will now read those notes which I intended to confine myself to, had not some allusion been made to another port, and had it not been said that the money could there have been expended with more advantage to the country, than at Dover. I cannot fail to admire the practical nature of the paper we are called upon to discuss, and I consider its appearance most opportune at the present moment. The Lecturer has dwelt forcibly on the arrangements necessary to be made for the more perfect utilization of our forces, both by sea and land. He very judiciously divides his subject under three several heads—1st. Defence of our Shores. 2nd. The Protection of our Commerce. 3rd. The Invasion of an Enemy's Country. He first directs

our attention to the necessity of placing all our ports, especially those facing the British Channel, in a complete state of defence, so that they may serve as harbours of refuge for our mercantile marine whilst moving up and down Channel against the attacks of an enemy, and he observes that well fortified coal depôts will be the natural bases of our operations during war. It must be evident from our greatly expanding commerce, and the value of time in all mercantile transactions, that our old system of convoys must fall into disuse. Moreover there is little doubt, that in the event of war, or in anticipation of any such event, the shipowners and the merchants of England will quickly perceive the increased safety of steamers, as they will be detained so much less time in the vicinity of danger, and at all times be far more likely to escape from the pursuit of an enemy. The lecturer has also pointed out that if these fortified coal depôts at home constitute important centres for operations and secure harbours of refuge for our mercantile marine during war, so also in an equally important degree do our fortified colonial possessions in every quarter of the globe greatly add to our maritime supremacy. A glance at the strategical map published in the Journal of this Institution in May, 1870, proves that these ports give us the most complete control over the outlets and currents of commerce, and yet there are parties who cannot be made to recognise these facts or to perceive that the complete utilisation of our steam marine depends on the position and efficiency of our coal depôts. General Collinson is not one of those who let such advantages pass unnoticed, for in this paper he states—"The completion of the Harbour of Refuge "at Dover would provide such a central position, fulfilling in all respects the require- "ments of a strategic harbour, and situated in one of those positions marked by "nature for the command of the sea traffic." It must be a solid satisfaction for him, entertaining such views, to know that the Bill for the construction of that harbour has passed the second reading in the House of Commons, is now in Committee, and the works will, I trust before long, be commenced. Having directed our attention to the sound policy of placing our ports in the Channel in as complete a state of defence as possible to enable us to set free for operations on an enemy's coast the largest number of both ships and men possible, I observe that he entertains, like myself, the notion that all future wars must be combined operations, that a purely naval war would be interminable and enormously costly; that a military force of considerable magnitude ought always to be held in readiness to act with the Navy, and that no port in England can offer such facilities for the rapid embarcation of our forces and military stores as the contemplated new harbour at Dover. It must not be lost sight of in the consideration of this subject that the success of such operations will mainly depend on the rapidity of our movements, and that these operations can be calculated at the present day by sea with far more accuracy than movements by land when great distances are contemplated. General Collinson states, with both truth and force, that "Naval operations will henceforth have their advantages over "land operations; they will be more secret, certain, and expeditious; they may "cover a large area of action, and the plans can be more easily changed." Moreover, an Army acting with an efficient steam fleet can never be deprived of its base of operations, for its base of operations will travel with it, that is to say, all its munitions of war and provisions. There will, therefore, be no such long line of communications to be kept up and protected as by land. Whole fleets of transports of a size even larger than the "Himalaya" have been called into existence since the opening of the Isthmus of Suez; therefore we can now transport with increased facility any amount of men and animals with both speed and economy. Two or three different modes of conducting such warfare will have to be carefully considered according to the exigencies of the service, and may be classed as follows:—First, the invasion of an enemy's country by small detached forces, termed by me flying armies. Secondly, with *corps d'armée* acting in conjunction with allies in an enemy's country, although possibly not from the same base. Thirdly, when taking the field in defence of the territory of an ally. When we only reflect upon the fact that this nation possesses capital, labour-saving machinery, and all naval and military resources greater than any two or even three nations in the world; that we are nearly the sole possessors of the most rapid and economical mode of transit to all quarters of the globe, viz., water; that the population of this vast empire, including India and our colonies, numbers 235,000,000 of souls; that the physical strength of

the British empire is more than doubled through the agency of machinery, it must be conceded that we are a long way from being *effaced*, and have not yet ceased, I imagine, to be estimated amongst the military forces of Europe.

Sir JOHN COODE, C.E.: Colonel Crossman has pretty well anticipated what I had to say, more particularly with reference to the harbour at Filey and the north-east coast; he has given you almost word for word a memorandum I lately framed in connection with that model to which he has referred, and which is now to be seen in the International Exhibition. With regard to the strategical position of Portland, I may mention a fact which may be of some interest in this Institution. It is so peculiarly placed with reference to Alderney and Cherbourg, that on one occasion —certainly on one occasion only—I was able to see Alderney from the top of Portland; and on another occasion, under very favourable circumstances, when very little air was moving from the south-east on a warm August day, upon the breakwater at Portland, I heard the guns at Cherbourg. These are facts which I think may be of some little interest, as showing the strategic importance of that great harbour. With regard to the supply of coal referred to by General Collinson, I may mention that there is stowage room at Portland for no less than 5,000 tons of steam coal, and has been provided for a number of years past. That harbour, I think, fulfils all the conditions which he mentions with reference to speedy coaling; it is very large, the water is deep, and it is sheltered, and there are a great number of the old mortar boats that were built for the Crimean War, which are now made use of, and very admirably they serve, for the purpose of coaling Her Majesty's ships. With reference to the proposed harbour at Filey, I do not think myself that the value of the position of Filey can be over-estimated.

Admiral Sir BARTHOLOMEW SULLIVAN: As one of the Royal Commissioners on Harbours, and as having had charge of the Harbour Department of the Board of Trade for some years, I am anxious to give an opinion on this point. I came here purposely (fearing no one else might have come), to say a word for Filey. I was one who cordially joined in recommending Filey, not only as the best harbour of refuge for the east coast, but as the only possible one at a moderate cost, and as the only possible one for a coaling station for our fleets in war. If it was important then, how much more important is it now, since a German Navy is springing up right opposite to it, and we have the possibility, at no distant day it may be, of seeing a European coalition in the north, acting against us. I have a horror of any war, and I trust that no war would ever break out between us and any Continental nation, but that ought not to prevent us making the country as secure as possible, and that will be the best preventive of war. Now it has been pointed out to you, what an immense extent of country there is on the east coast without the means of coaling our fleet. Between Sheerness and the Frith of Forth there is literally no place. At Filey we are just half way, just abreast of the German port, which you see marked in the east corner, and you could not fix on a better spot for a position for our fleet, independent of its local advantages. It has local advantages such as no other place on the coast has for making a harbour except Portland. It is a singular fact, which Sir John Coode will bear me out in, that the geological formations of Portland are exactly the same as those at Filey, only reversed. The secondary formations run in a north-east direction from Portland, and end in Filey Bay, as though the two places were made for the same purpose. I believe I am right in saying that the Kimmeridge clay forms the bed of both harbours, so that the holding ground is excellent. Filey is within reach, by numerous lines, of all our coal fields, and it affords just the facilities for protecting a coal depôt that one gentleman has so well pointed out as a necessary part of a naval harbour. The coal need not even be put afloat. I believe it would be possible to bring the train down a line of jetties, carried far enough out in some place for our large ships to come alongside. If so, the coal could be kept a little in land, out of the way of any enemy's guns, or of any one reaching it, and could be run down on the jetties when the ships want it. I will mention one point in connection with Filey which should not be overlooked. We did not look to Filey being a large naval port when we recommended it, and I think the altered state of affairs in Europe would justify a rather larger harbour being made, than we recommended. I would carry the breakwater out into one fathom deeper water. I think £1,000,000 spent on such a work as that would well repay

us, and then we should have plenty of room under that breakwater for our largest fleet, and could leave all the shallower part of the harbour for our wind-bound and refuge vessels. The rock lays there already for the work. Filey has facilities for construction such as we find at no other port, and there is no place that can compete with it as a point for the refuge of our coal trade. That was clearly brought before us by evidence taken in all the northern ports. And I may mention one fact, that while everybody said their own port was the best, they all said that the second best was Filey. That is, I think, conclusive. As attempts have been made in Parliament by men in high position to throw doubts on the estimates of the Royal Commissioners, and to accuse them of not having gone carefully into them, so that probably the work would cost two millions instead of one, I feel it right to say, there are not the slightest grounds for such an accusation. The estimate was calculated on the ACTUAL COST of Portland breakwater; and its correctness was proved by the fact, that Messrs. Rigby, the contractors for Holyhead Harbour, authorised me to say they had gone carefully into the plan on the spot, and were ready to construct the harbour at Filey for the estimated sum, giving guarantees for its completion. I do not think that the Lecturer need have apologised for not being a nautical man. There are very few nautical men who would not say that he has put the whole question before you as well as any nautical man could have done. There is much in what he has said that is as important as anything that can be brought before the country in this day. With regard to Dover. I believe a fine harbour at Dover may be very valuable, but I would not estimate it as of the same value as one at Filey. When you have three fine ports in the south opposite France, and you have none opposite the northern nations, then I do say that one harbour on the east coast would at present be of more value to us than Dover would. I am not an alarmist: I am not one of those who, like the writer of a well-known pamphlet not long ago, supposed that a German Fleet is going to eat up our Fleet and then invade the country. I think anyone who has gone fully and fairly into the nautical question would have said (what might be the case) that England's Fleet might be drawn away by distant wars, such as in America, and so leave the country with a small fleet, and then the danger might come; but to leave us our whole Fleet and to have it destroyed by a German Fleet was, I think, really trifling with the matter and undoing the value of what was written. That is my own estimate of it. I wish to advert to one point of the subject which is very important. You have heard a good deal about the advantage of having points in different parts of the world for the protection of our trade. I have tried hard for a long time to get a little notice paid to what I believe to be one of the most important of our foreign points of that kind. If you will look at the end of South America, where a very large traffic comes round, you will see a little group of islands called the Falklands. Now the whole of our rich Australian gold trade as long as it comes in sailing ships will come round that point. It is a fact that when there was a prospect of war, that point was fixed on immediately as the place to which these valuable ships should come and meet convoy; yet the beautifully secure harbour, where all the trade from Australia might go, is so undefended, that a single corvette of any enemy could go in there and destroy the whole of the ships when they were there, and all the place too, and burn it all down, for the want of some half-dozen good guns in little forts on the hills which command the harbour in every direction. This is risking a point which one day may be very valuable to us to protect our Australian trade homeward bound. A few guns and a couple of hundred of men in garrison, with Volunteers furnished by the Colonists, would be all that would be required to make a safe place for our ships to call at. There is one thing that we must not overlook with reference to the question of invasion. All the writers on the question of invasion that I have seen, have made much too light of the difficulty of throwing a large army on an enemy's coast. Those who served in the Crimea know that it took two days *unopposed* for the large fleets of England and France to land 50,000 men. I do not think that that has ever been properly estimated in considering the chance of invasion. But if our fleets were drawn away it is a danger of course, and I should look to this as the principal thing, not only for the defence of the country, but for keeping peace and making it too great a hazard for any nation to attack us, viz., to make London secure against attack. When our ports were equally exposed with London there was the chance of

Plymouth or Portsmouth being made a dash at and destroyed in a fortnight perhaps by an invading force, but now they are made secure, it is certain that no enemy, particularly from the south, will do anything but try to make a dash on London. You have made this the more certain by finishing your arsenals, and therefore what we want now to make invasion almost too hazardous to attempt, is a good system of encircling London with forts, in which the irregular forces of the country should assemble, so as to leave our own regular Army to work before the enemy in the field.

Sir JOHN COODE: Admiral Sullivan has appealed to me in support of some remarks that he made. He said the conditions at Portland and at Filey were reversed. What he meant, no doubt, was this—that Porland and Filey are at the two extreme ends of the great chalk range of Great Britain, and that you have in Portland Bay the tenacious blue clay called locally the Kimmeridge, from the village of Kimmeridge, and at Filey you have the Speaton clay, which is a local name from the village of Speaton. This clay is of a remarkably tenacious character, and a better anchoring ground I do not know. A model has been referred to this evening. I may say that my views entirely accord with those of Admiral Sullivan. I furnished the lines of the works on that model, and Admiral Sullivan will find it is larger and more comprehensive than the design recommended by our Harbour of Refuge Commission in 1859, and that it does go into a fathom and a-half or nearly two fathoms deeper water.

The discussion was then adjourned to Monday, the 27th inst.

ADJOURNED DISCUSSION.

Monday Evening, April 27, 1874.

COL. W. F. DRUMMOND JERVOIS, C.B., R.E., Deputy-Director of Works for Fortifications, in the Chair.

Major EDWARD HARDING STEWARD, R.E.: Having been instrumental in moving the adjournment last Monday, it falls to my lot to make a few remarks upon the very excellent lecture given by General Collinson, a lecture which was listened to with the very deepest attention. In order to have a good discussion, it is absolutely necessary that there should be a good difference of opinion. I feel in this case—certainly on my part—that there are very few differences of opinion with the Lecturer, I can therefore only enlarge on two or three points that he has named. General Collinson remarked on the necessity of securing the basis of naval operations, in order that in time of hostilities a war of offence may be undertaken. This was fully explained, and after alluding to our imperial duties in a war in which this country might be involved, the Lecturer truly observed that the number of ironclads available for home defence would not be "over large." Now, the revelation recently made in another place respecting the number of efficient ironclad ships, causes this subject to assume an unusual importance. It would be interesting if General Collinson, or some naval officer who may have studied imperial war policy would state the number at which he would place the seagoing ironclad ships available for home defence, supposing that proper provision is made for the requirements of the Mediterranean and North American stations, and the greater ocean highways. The number would be small, so small as to disconcert those who appear to expect the British fleet to be ubiquitous during a time of hostilities. It will even disconcert those who, looking only to home defence, expect the fleet to be always in the *right place* at the *right moment*. A great deal has been made in the lecture on the subject of the defence of our now very greatly increased commerce, for we may depend upon it, the mistake made by the French during the war in the early part of the century, of giving us the opportunity of defeating then *en bloc*, will not be repeated. The plan adopted will rather be the harrying of our coast and of our commerce by any nation,

or combination of nations, with whom we may be at war. With regard to our coasts, as was explained in the lecture, the securing the doors of the stable is the precaution one would naturally take, and then the making of some dashing bold strokes against the shores of our enemy would be the next move—bold strokes, that would cause him to look at home, or at least to distract his attention. Unfortunately for us, this last *cannot* be done without the other. We must secure absolutely the defence of our country at home before we can do all these kind of things. A distinguished naval Officer, Sir Bartholomew Sullivan, who warmly advocated last Monday the claims of Filey Harbour, and who has studied imperial war policy a great deal, thoroughly appreciated the advantages that would accrue in war from freedom of apprehension as to our safety at home in giving scope to our offensive moves; he even urged the protection of the Metropolis. This precaution would undoubtedly set free a large portion of our force, and enable England to carry the war away from our coasts, a point so ably advocated by General Collinson. There is no greater mistake, I believe, than to have a war at home. The economy attending the adoption of a defensive war-policy was also dwelt upon. Now, if we were to adopt a defensive policy, it would be very difficult on our part to bring a war to a conclusion, and while the war would be languishing, what is to become of our commerce, our commerce which, even under the most favourable circumstances during war, could not be on the extensive scale usual in time of peace. One may well say that commerce is to England what the circulation is to the human body; and that though a feeble and restricted circulation may be supportable for a time, it subsequently leaves its mark. Restriction in commerce, extending over a year or so, would mean to us the loss of very many millions, by the side of which our naval and military expenditure may well be represented by the traditional flea-bite. Being on the subject of economy, I would suggest that anyone who is fond of statistics might find it very profitable to compare the loss to the nation at large occasioned even by a small panic on 'Change with the cost of placing ourselves in a position to disregard the fluctuations in the European political barometer. It may at first appear a small thing to *us* who do not very often have much money invested in business, but it would follow from our reflections that preparation for war is the cheapest course in the end; and if war be inevitable, a quick and decisive war, one which we can remove far from our own shore will be the least onerous to us. General Collinson has well described the increased interest now taken in military subjects. The interest is now much increased as compared with that of a few years back. But interest *does not* always imply a corresponding amount of knowledge, at least with the thinking portion of the public. Now, I may say that one of the disadvantages of a popular form of government, in a military sense, is, that great and most necessary measures of expansion can only be undertaken when fully supported by the public. The education of the public on points connected with war is difficult in the extreme. Lectures rarely meet more than a few strata, and moreover the lessons of war experienced by our neighbours only produce in this country unpleasant feelings, which last for a time, and then speedily fade away. The press, the great instructor in other matters, cannot be always depended on in this case, at least, to judge by some remarks made by a leading journal a little time back. According to the war-policy then enunciated, we appear to have to defend a country co-extensive with the old Heptarchy, and not the British Empire as we now know it. The whole lecture was, I take it, a protest against this narrow view of our war-policy, I therefore trust that it may have the widest circulation, and that the hint General Collinson gave, that the details of joint naval and military expeditions should be *worked out in time of peace*—that is, that we should apply to naval operations the well known Prussian War Office system—may bear fruit.

The CHAIRMAN: We should be much obliged to Mr. Reed if he will favour us with any remarks he may have to make upon any of the matters which are referred to in General Collinson's paper.

Mr. E. J. REED, C.B., M.P.: Mr. Chairman and Gentlemen,—I am very sorry to have to pay you and the author of the paper the poor compliment of speaking to it without a more serious study of it than I have been able to give. But one thing struck me on the perusal of the paper, that is, that General Collinson has taken a very broad and a very serious view of our responsibilities, with reference both to

our home defence and to our interests abroad, and in obedience to the invitation which you have given me, I will venture to add a few observations upon the subject as the result of long consideration. The last speaker has referred to the effect of popular government upon these questions, and I think we may take it for granted that the influence is a very restraining one. But it is becoming so general, that we may almost now, I think, leave it out of consideration. I do not know of any great European Power which has the means of conducting its naval and military operations, or even of regulating its naval and military forces, without reference to the popular will. We have lately seen in Germany how serious a question arose between the Government and the representatives of the people, even when the Government desired to give an answer in substance to the seven years' tenure of office by the French President, and which almost resulted in a serious national difficulty. And even in Russia, where the Government is more personal, and has more power than in any other country in Europe, we all know the Government is much restrained, not exactly by the organised representation of public opinion, but by the existence of public opinion, and by its expression in the Press and otherwise. We may take for granted, whatever the disadvantages may be in this country, they are pretty common, or are becoming pretty common to other countries of Europe; the disadvantages we experience are either experienced by other Powers, or are rapidly becoming so, and, as Major Steward has well observed, and as General Collinson indicated, it is very desirable to educate the people in these matters, and as he also showed, they are exhibiting a great desire to become educated, for they take the greatest interest in naval and military questions now. In fact, I doubt whether even the financial proposals of the Chancellor of the Exchequer, with an enormous surplus to distribute, have excited the same interest in our Parliament this year as the mere suggestion that our Navy was weaker than we thought. Now, Sir, it seems to me that we must take it for granted that under a popular Government we shall be limited in the amount of money we can appropriate to the public services, the Army and Navy. After some official experience, I am bound to say, that in my opinion. it is neither the necessities of the Army nor the necessities of the Navy that regulate the expenditure upon the Army and Navy; it is the amount which it is convenienc in the view of public and political feeling, to appropriate to these services, that these services get; and we saw, even this year, that when the Minister for the Navy was disposed to draw rather a highly-coloured picture of our condition in an unfavourable sense, we very soon had another Minister telling us that, after all, the Government saw no occasion for doing much, and did not think much was necessary; showing to us that it is not the state or the requirements of the service that regulate the expenditure upon it so much as the public and political necessities and circumstances of the time. It is useless to find fault with this; all Ministers are alike, and all Governments are alike; they all find fault with one another because this is the case, but they all practise the very same thing when they become responsible. Therefore we must take it for granted that it is our normal position, and we must endeavour to do the best we can under it.

I am one of those persons who believe that the defence of our coast should, in a very large degree, be assigned to permanent military constructions, and to volunteer naval artillery forces, and I believe if we would put a little more thought and a little more serious organisation into the question of coast defence, we might defend our coasts in an infinitely better manner than they are defended at present, with a very moderate increase of expenditure indeed. It will, for instance, be admitted I believe, by naval and military Officers alike, that it would be a most valuable element of coast defence that we should be able to send a number of large guns in very small vessels out of the various great ports of the country. People talk about sending very large guns to sea, for ocean purposes, in very fast and very small ships. In proposing that they dream, because you cannot get a very small sea-going ship to go very fast even without a big gun, and with it, it is an absolute impossibility. I for one would certainly advise the direction of the thoughts of naval architects to the continual improvement of our position in this respect—to sending to sea the biggest guns in the smallest ships, and with the highest speed we can. At the same time, it is useless to suppose that in sea-going vessels we can—at any rate for a long time to come—do any very great things in that way. But to send small vessels

carrying large guns out of our ports for the defence of our ports is precisely what we can do, because there we do not want any great speed, and we do not want any great coal-carrying power. Therefore it is quite easy for us, if we have the wisdom and the will, to send out of our ports big guns in little boats, and Mr. Rendell, of Messrs. Armstrong's firm, and my friend on my left, Major Moncrieff, have shown us, each in their respective manners, how this may be done. But I go on to say that it is a very foolish thing for Government to invest money in producing a multitude of these little vessels, and then to lay them by. In my opinion, what we ought to do is this: we ought to decide upon the vessel we require, we ought to produce those parts of the vessel and of the engines which we cannot produce quickly, and we ought to finish as many of the vessels as we want for training purposes. For instance, take the case of any port, supposing it shall be said that for the defence of the Humber we ought to send thirty of these powerful guns out in time of war, and when necessity required. Then I would say build a couple of the thirty vessels that you want, or three if you like, in which you can train your forces, which shall be chiefly volunteer. They have simply to drive the engines and work the gun, and there are abundance of men in the port of Hull to man the thirty vessels as volunteers. Of course you would give a certain infusion of regular forces among the volunteers, which is always desirable, because of the superior discipline and steadiness which you get from highly and permanently-trained forces. Well, then, I say, I would build two or three vessels essentially for training, and I would provide those parts, such as the forgings of the ship and engine, which you cannot produce quickly, for the remaining 28 vessels. Then if the probability of war approaches, I will venture to say in a fortnight, or, at the most, in three or four weeks, you might turn out the 30 vessels, and you would have already passed through the two or three finished boats, the number of trained men requisite to man the whole. By adopting a policy of that kind, in conjunction with our land fortifications, and our mid-water forts, and with other adjuncts, you might, in war time, make the whole coast of the country (without any large expenditure, and with a very wide use of your maritime population), bristle with big guns; and whatever opinions gentlemen may entertain about the essentials of coast defence, I think they will agree with me such a force as that cheaply obtained—for the guns would really be the principal expenditure in time of peace—would be a most valuable element of security to the coast of the country. Then the next thing is, we have our commerce, and we have our foreign possessions. Now I must say that I believe, notwithstanding the break down of the various attempts in past times to utilise the mercantile marine for military purposes, in these days of iron steamships we might, with a very moderate expenditure upon certain of our mail and other vessels, adapt them for the carriage of certain guns; and I believe I could point the Government at this moment to three or four companies existing, or in course of organisation, possessing ships faster than the great bulk of our men-of-war,—because they are much larger and speed is their first requirement,—in which, for a very small outlay, provision might be made for the reception of guns in time of war. But there again I am afraid the Officers of the Army, and particularly of the Arsenal of Woolwich, will think I am laying a heavy burden upon them in the way of manufacturing guns; should they, however, find it too great, we can find means of assisting them. Here again I say the guns and ammunition would be the principal things we should require, in order to turn our mercantile fleet, or certain portions of it, to very valuable use in time of war. If convoys were necessary for the proper carrying on of our mercantile operations in time of war, we might with a ship like the "Inconstant," or the "Shah," or the "Raleigh," at the head of half-a-dozen mercantile vessels armed with guns in the way I have suggested, have very powerful convoys, which no fast vessels sent out by a European or other Power could possibly oppose. We might thus, I believe, pursue our trade on the great lines of commerce in very considerable security. That sets the great bulk of our war fleet free to do what, in my humble judgment this country never ought to dream of foregoing the power to do, that is, of carrying war upon the coasts of those Powers which choose to make themselves our enemies. I am sorry to say, in my opinion, we very much underrate the necessity of this country even for that purpose. Nothing is more common,—I have often heard it when I was not a member of the House of Commons, but when

I used to sit under the galleries as an official person, and listened to the wisdom that emanates from the members of that place,—I used to hear members rise and say: "The first thing it is our duty to do is to be as strong as all the other Powers of "Europe put together in ironclads;" and I have known it to be stated lately, during the discussions that have occurred since the speech of the Minister last week, that our ironclad Navy really is after all, equal to all the other ironclad navies of Europe put together. I am as proud of our Navy perhaps as anybody, as I had a good deal to do with building it, but I think that is a very great overrating of our Navy; and I think you would find it so if you brought it to this simple test. What has our Navy cost? and what have other Powers expended on their navies put together? I do not understand that the English people or Government have any right to assume that our ships are designed or built with any great superiority to other ships. I know very well during the seven years I was the chief designer of Her Majesty's ships, that I never discovered, from the Government or the country, that I was deemed a marvellously skilful and deserving naval architect, or that I had done a great deal for the country more than all the other naval architects of Europe. If that was so, it was left for me to find it out in some other way; but I dare say the general opinion was not to that effect, and it is fair to assume, making allowance for a little pardonable national pride, that on the whole, considering the extent to which other Governments have built in this country, considering the close imitation which they adopt of our methods, and considering the skill and genius which they themselves bring to bear upon the subject, we may take it for granted the country ought to be satisfied with regulating their power, and presuming other powers also to be regulated, by the expenditure upon new ironclad ships. Now, if this country imagines that it has spent upon ironclads as much as all the Powers of Europe put together, it is very much mistaken, and therefore I maintain that it is an abuse of national pride or national vanity to assume that we are so very strong. I think we are strong comparatively, for this reason, that for seven years at any rate we adopted this policy,—that whenever we laid down a first-class ship we made her superior, not in disputed points (because I see gentlemen around me who would dispute a great many of the features of the ships that I designed), but superior on points which are not liable to dispute: superior in thickness of armour, in weight of armament, in speed, and in other measurable and quantitative qualities to the ships that had gone before. I believe it would be an unfortunate thing for this country in these days to adopt any other principle than a determination to build the best and strongest vessels. I know there are many people, and I believe they are among the wisest of the wise, who say that this clinging to armour is a perfect delusion, because some day or other the gun will invariably beat it, and then where shall we be? Well, sir, I for my part never designed ships in a prophetic spirit, and I never want to build them in a prophetic spirit. I may claim, however, that we have been, ever since the introduction of armour plating into our Navy, strong, because we have adopted it, and strong because we have gone on with it; and although I believe as much as anybody that the day will come when we shall do away with it altogether, I think we should be in the highest degree unwise to do away with it at present. What is a ship without armour? It is a ship with her crew and armament sent to sea upon the top of a steam boiler and a powder magazine. I do not know that that is an unfair definition of an unarmoured ship, because you may make no account whatever of the mere envelope that encases the engines, boilers, magazines, and so forth; and for my part, if I had to fight an action to-morrow, I must confess I would very much rather fight it in the "Devastation," with all her very great disadvantages, to fighting it in a ship which had a steam boiler and magazine underneath my feet, and nothing to protect them from the enemy's fire. However, apart from this particular aspect of the question, I do maintain that our Navy is not a bit too strong to represent our power in the presence of possible combinations of other navies. As a matter of fact we often underrate the powers of other navies, and I say this knowing what I am saying. I know that in the autumn of 1872 I got into a little trouble for calling attention to the progress which other Powers were making and to the want of progress which we were exhibiting. I must say events have a little interfered with my views at that time, for this simple reason, that, through accidents and through other causes, foreign Governments have not made the degree

of progress which it was then fair and right to expect of them. Take that famous "Peter the Great," the name of which excites so much feeling in some persons' minds. I was told the other night by a gentleman who not long ago was a responsible Minister, that I really had so written about the "Peter the Great" as to make people imagine that she might turn up at any moment in any of our ports. Well, gentlemen, it is one thing to write a thing and it is another thing to read what somebody else has written. I can only say that if anybody would refer to what I wrote they will not find a syllable in my words to justify such an expectation. All I said was that the "Peter the Great" was under construction and making considerable progress, and I described what I had seen. The Russian Government have been very unfortunate in connection with this ship, inasmuch as in the autumn of last year two cargoes of her armour plates were sunk on the Dogger Bank. One ship went out from Hull with one cargo, and the plates got adrift inside of her, or something was wrong outside of her, and she went to the bottom with the plates. A week afterwards another ship did precisely the same thing, and you can easily imagine it is a little embarrassing to a Government to have its 14-inch armour plates sunk upon the Dogger Bank instead of being delivered at St. Petersburg. That has thrown "Peter the Great" back; and for my part I confess the effect of that has been to pass the "Peter the Great" out of the front rank of war ships and put her into the second rank. On account of the agitation some of us got up, we did induce the Government to make a little more progress than they were doing. However, it is well known to gentlemen that the Russian Government have not been slack; they have been making progress, and are not by any means to be despised as to their naval position. I do hope gentlemen will not reserve all their wisdom on this subject until after the event, but will remember the Russian Government are building vessels which are capable of resisting our heavy ordnance and of carrying still heavier. The German Government has not made the progress with its ships that I expected,—from various causes connected with men and connected with the want of general means to advance these constructions with the rapidity which we are accustomed to in this country; and I must in fairness add, partly owing to the slow progress of their ships in this country. But making all kinds of allowances for these things, I maintain no man competent to deal with this question can sit down and make an impartial review of the naval forces of Europe generally, and say that we are in a pre-eminently satisfactory position, either at the present moment or looking a little to the future; and, if that be so—if it be necessary, as I believe it to be, to throw more expenditure upon our gea-going fleet, then I must say the inference I drew that we ought to defend our coasts as much as possible by these secondary and auxiliary arrangements, stands more confirmed than ever.

I am afraid these remarks are not as pertinent to the paper as they might be, and I well know that there are parts of the paper to which I should have the greatest pleasure to refer, if I could do so at all worthily, but I cannot. I feel this point, however, very strongly, viz., that we ought not to be in a position to have to trust to taking from our seagoing fleet in any degree for the protection of our coasts in time of war. We want a squadron in the Mediterranean undoubtedly; we want a Channel squadron, and we ought to have a North Sea squadron in the event of any war whenever it may happen; because in these times, although you may go to war with one power, you may find yourself at war with two or three in a week's time, and, as gentlemen of this Institution know perfectly well, the developments of war, like the operations of war, may be extremely rapid. Therefore, we ought to be prepared.

I may say one thing with reference to this point that is quite pertinent, I hope, to this discussion; that is, the assumption that the waste of the boilers of our ironclad fleet is unexampled and unparalleled. Now, the first remark I would make upon that is this—that he would be a very improvident owner of a steam-ship who would take out the boiler of his ship the moment it ceased to be perfect, the moment it became incapable of carrying full steam; or, if not exactly incapable, yet when it ceased to be advisable to carry a full pressure of steam. Gentlemen will know perfectly well that in the case of a steam boiler, as in the case of a bridge, or any other construction, you always allow an enormous margin beyond what the thing has to bear, and what it is supposed to be capable of bearing. We test every steam boiler

far beyond the pressure that will come upon it, and much of the alleged incapability of the boilers to sustain the proper pressure is due to the simple fact that, after a certain amount of wear and tear, the professional gentlemen say, "Well, we advise a reduction of the steam pressure by a certain amount." The chances are that the boiler in which that reduction takes place would be capable of working even for years with the original pressure, if you choose to invade the margin of safety which it is deemed prudent to provide. I therefore would lay down the proposition that we ought not to say roundly and broadly that every boiler in a man-of-war which it is deemed imprudent to work up to the full pressure should be taken out of it. We should have to be a very rich country indeed to carry out that policy. There is one other proposition which I will put upon the other side, that is, that when you, from any cause whatever, wise or unwise, deem it desirable to reduce the pressure, so as to take away very largely from the steaming power of the ship at her best, then it is time to take her boilers out.

The CHAIRMAN: I am sure these observations are exceedingly interesting in themselves; but as the time of discussion is limited, I think I must ask Mr. Reed to keep to the point of the paper. The question before us is rather with reference to general considerations relating to the maritime power of the country. No doubt, incidentally, the question of the construction of ships and boilers, in which I feel myself greatly interested, is in some degree to the point, but I think we must apply some limit to the details in these minute particulars.

Mr. REED: I watched very closely the comments made upon the paper by the gentleman who preceded me, and I was watching still more closely the feeling of the audience, to see that I was not trespassing beyond their interest. After the suggestion which has been given me from the chair, however, as the Chairman must understand the object of the discussion and the temper of the audience so much better than I can possibly do, you will excuse me if I bring my remarks rather abruptly to an end, and content myself with the general observations in which I indulged, I may say by your invitation.

The CHAIRMAN: We have had the naval side of the question. Perhaps some gentleman may follow, taking up any views that he may like to express on the land view of the question.

General EARDLEY WILMOT, R.A., F.R.S.: I gladly rise on your invitation, because I differ from the two gentlemen who have preceded me on one very main element. They spoke of educating the people, but in my view it is not in cases of this sort the people that require educating, it is the Minister. When a Minister comes forward and states plainly what is required for national defence, the nation comes forward at once to do it, and I think it is very hard upon us who are the "people," that we should have to bear the blame of the alleged shortcomings of the Government. As regards the paper of General Collinson, I must, if he will permit me, add my testimony as far as I am a judge, to its extreme value and pertinence, for the question requires ventilation throughout the whole country. We want the people to understand that England is not the country. England, to my mind, is simply what Paris is to France—the capital, and nothing more. Our first duty is to make the capital secure, but if you make your capital secure and neglect all that surrounds you in your colonies, you are doing only half the work. As regards the necessities of ports, which is an essential element of General Collinson's paper, it seems to me it is not necessary for us to look along the coast to find existing ports, but necessary to determine the place where a port shall be, and considering the power, the skill, and wealth of the country, at that point where military and naval science says the port shall be, there it should be. From it to the great centre depôts of coal and so forth, lines of railway should be laid down for the express purpose, if necessary, of supplying all that is required to those ports. In the defence of England as the capital, the notion put forth by Mr. Reed of the small vessels is a most important one. But I cannot forget also that as Paris has its great outworks around it, so in our island these great ironclads are our advanced forts, having the supreme advantage of not being fixed here and there, as they are round Paris, but being movable around our channels and capable of taking up a position of defence wherever they are required. As it is impossible to surround our coasts with permanent fortifications, we possess a supreme advantage in being an island in this respect, and are

more defensible than any capital like Paris. Further, in considering what should be the defence of the country, it is not necessary for us to enquire minutely as to what other nations can do, but simply to assume that they can do all we can do ourselves. If we assume, as we have every right to do, that they when combined can do what we can do, we have a standard, and we shall know exactly the proportion of defence we require against them, and until we are satisfied that we are in a proper state of defence, we shall not feel perfectly happy. With regard to depôts, it happens we have got our great depôts upon the coast. It is a very unfortunate thing that we have, for there is not the slightest reason why the great depôts of stores and so forth, considering the power of railways, should not be inland rather than on the coast.

Major MONCRIEFF, F.R.S.: To bring back for one moment the very important subject under discussion to the point it started from, namely, to the question of the formation of strategic harbours and depots on our coasts for supplementing our naval forces. The discussion to-night has been more directed to the Navy and the ships themselves, but I should say the question more immediately under consideration was how much of the resources of the country should be directed to increasing the ships and floating batteries, and how much to the harbours and depôts required to support these vessels in time of war. The great feature which must strike any one who glances at a map of England in relation to this subject, is the number of places which might be or are adapted for depôts and harbours on the south coast of England in comparison with the advantages of the east and north-east coast in this respect, which is comparatively unsupplied with proper harbours or depôts, either for mercantile or war purposes. It appeared to me the arguments adduced in favour of a harbour at Dover were very strong, so strong indeed that I felt prepared at once to endorse every opinion of the gallant Officer who adduced them (Captain Hoseason). When one casts one's eyes, however, to the north of the map, it struck me that the arguments in favour of the other positions were, if possible, even stronger, and if one could only carry the mind a little further north than *our* map goes, I believe this impression would be confirmed. I am sure that a great deal might be said for doing something for the only position in which vessels of war can at present take refuge between the Humber and the Moray Frith, a distance of about 400 statute miles. In that very extensive and important reach of coast, there is only one place where vessels of any kind can take refuge, namely, at St. Margaret's Hope, and some other anchorages further down the Firth of Forth. I happen to be well acquainted with that particular district, and I can say that nothing whatever has been done in the way of either forming what would be now considered proper war depôts, or protection for our own cruisers pursued by a stronger force. I think that good cause has been shown in General Collinson's most able paper, and in the dicussion that something should now be done on the north-east coast both at Filey and the Firth of Forth. I should have felt inclined to offer some remarks on a part of the subject on which I am specially qualified to speak, and which remarks would have been directed towards urging for land service an analogous proposal to that of Mr. Reed's admirable one for gunboats and sea service, and on the same principle of expending money only on what takes a long time to create; but I think it right to refrain entirely from entering into any question that in relation to the subject before us would be one of detail.

Captain ARDAGH, R.E.: I desire to make a few remarks about Mr. Reed's suggestion for the provision of small gunboats in our ports, for their protection in time of war. Mr. Reed has stated—and no doubt he is the very best authority we can possibly have on the subject—that these small boats might be prepared in a month's time. I think a month would hardly be sufficient time to allow, and even assuming that it was, I think within a month the crisis would have passed. Over and above that, I am firmly convinced gunboats are certainly not the best method of disposing of our guns for the protection of particular ports. Our gunboats and our Fleet generally, we may assume as our active Army of the sea, which must be always on the move, and should aim at carrying war into the enemy's waters, and blockading his ports. What we have to do for the protection of our smaller ports, and even of the great commercial harbours and arsenals, is to provide security for fixed points; and for the protection of definite points, there is nothing so efficient and so econo-

mical as a gun fixed on shore, for these reasons—that it is always there; it cannot run away; a shot cannot sink it; a ram cannot penetrate it; a torpedo cannot blow it up; and it costs one-twentieth part of what the same gun would cost placed on board ship.

I observe, in reading General Collinson's paper, that a discussion took place with regard to the harbours at Dover and Filey. Dover Harbour, I understand, is about to be completed, but in respect to Filey (or, in more general terms, upon the desirability of a harbour on the east coast in which ironclads can coal) I hold very strong opinions indeed. We have now got, as Colonel Crossman very ably pointed out, no harbour whatever on the east coast, and we cannot pay too strong attention to the arguments which he brought forward to prove the need of one. Sir John Coode also pointed out the advantages of Filey; and the fact is, an armour-plated ship in a blockade of the northern coast of Europe, would now have to go to the Thames, or Harwich, or Dover to coal, for there is not a single harbour on the east coast to which armour-plated ships could safely resort; and even Dover at present is not in that position. With respect to the fitting out of those merchant vessels which Mr. Reed alluded to, there is a point which General Collinson has mentioned, namely, that one of the great naval powers of the world has not yet given her concurrence—nor is she at all likely to do so—to the general agreement against privateering. And I am very strongly inclined to think that in the event of a great war we should have to reconsider our position on that question. I do not know how we could manage it otherwise. We have all these merchant vessels available, but how are we to commission them? We cannot turn them all into ships of war. We could not provide naval Officers to command them or enrolled seamen to man them, and it seems to me we have no other mode of getting out of the difficulty than that of giving letters of marque. It is a very serious question, and one which deserves consideration.

We have heard it stated here to-night that our vessels of war, our large ironclads are to be considered as our forts, and the smaller ones as the fixed defence of the coast. I do not agree with that idea. The ironclads must be considered as a mobile and an offensive force, and not an immovable and passive one; and if we want to defend our ports we must erect forts for their protection, and as incomparably the cheapest mode of doing it. It would be perfectly preposterous to employ an ironclad to defend a port when you could construct a fort at one-twentieth of the cost of the ironclad, and put one-sixth of the *personnel* into the fort to defend it.*

Mr. S. J. Mackie, C.E.: I was struck with what I think is a very essential feature in General Collinson's paper, and that is, the provision which he deems necessary, other speakers concurring, for rendering the defence of our coasts effective, so as to liberate the Navy of this country for offensive warfare. I think, also, the strong position which Mr. Reed took with regard to the encouragement of the Volunteers, using them not only ashore but afloat for the defence of the country, is a very valuable one. One point which has been omitted seems to me to be an element of consideration, namely, the possibility of using our mercantile mariners and seafaring population with very great advantage, and in point of fact, organising the available resources of our shores by a volunteer naval force. I cannot say I agree in sending

* A few comparisons of what may be got for the same money in the way of ships and forts will be rather astounding:

The "Rupert," with 3 guns and 9-inch to 14-inch armour, cost as much as the Plymouth Breakwater Fort with 22 guns and armour from 15 to 20 inches thick; or as Hurst Castle Battery, a casemated work for 61 guns with 21 inch iron shields. The "Glatton," with 2 guns, cost more than Picklecombe Battery with 42, or Garrison Point with 36 guns, these works, too, being casemated with iron shields. For the cost of the "Devastation," mounting 4 guns, with 10-inch and 12-inch armour, seven earthen batteries, like that at Southsea, mounting 217 guns, could be constructed. In addition to the immensely greater first cost, the expense of ships of war is greatly enhanced by the annual expenditure in repairs, renewal, and risk, which, in the case of forts, is insignificant, and by the more numerous *personnel;* for it takes at least four times as many men per gun to man a ship as are needed in a land battery.—T. C. A.

a crowd of big guns to sea in small ships. I would much rather see the energy of a maritime population brought out by training and practice with such weapons as Harvey's torpedoes, which, I am sure, would prove to be exceedingly effective in the hands of skilful sailors. The use of such a weapon as this could not require naval Officers or naval seamen. I have myself been out with Mr. Harvey from Yarmouth in a common tug-boat, and have seen the master of that tug-boat most effectually strike with a dummy torpedo every vessel which came in sight. And I am sure a great deal might be done in this method. Steamers of high speed, armed with such weapons as the towing trpedo, might be left to take care of themselves. And if torpedo warfare is looked to thoroughly as a means of helping the mercantile Navy to help itself, it will be another essential element in carrying out General Collinson's main point, that the defences of the country be kept up effectively, so as to liberate the Navy for offensive purposes. No doubt it is along the Channel, in view of the possibility of having our nearest antagonist to deal with, that we require most defence, and from Land's End up to Harwich, or thereabouts, the main necessity exists for forts and also for coast vessels. The longer distances, I think, would be effectually taken care of by the Navy; but, in my estimation, the port of Dover demands the most earnest consideration, not only on account of its position, but also on account of its traffic, and its nearness to France.

Captain NEEDHAM, R.M.A., Assistant-Professor of Fortification, R.N. College, Greenwich: The third head under which General Collinson divided his subject was that of the invasion of the enemy's territory; and I think that he enunciated that for this purpose a military force of considerable magnitude should always be held in readiness to act with the Navy, and that harbours should be specially prepared to afford every facility for the embarkation of troops. But I think he scarcely mentioned, or at all events laid very light stress upon what would seem to be a third and most important element for the successful accomplishment of such combined operations, namely, the arrangements which must be made beforehand to ensure that there shall be at hand betimes a sufficient number of steam transports to embark without delay the expeditionary force of which he spoke, and such stores as must necessarily accompany it. No doubt in time almost any number of powerful and capacious steam ships could be gathered together, collected from our great ocean steam companies, from our mercantile ports, from the Thames, the Mersey, and the Clyde; but to get hold of these in the first place, to charter them, to make such arrangements as might be necessary to enable them to carry troops, would be a work of time. And I think that General Collinson laid down that the success of our operations would depend mainly on the rapidity of our movements. It is notorious that the Prussians deemed it necessary to have time-tables worked out for the calculation of their forces at any point, whence they may deem it necessary to concentrate them for defensive or offensive operations. And if "the sea is to become England's base of operations," it seems to me that we ought also to have arrangements made in time of peace to enable us to carry out with certainty and celerity the transport of our troops across it in time of war. It may be said that the Navy would be able to perform this task of conveying our troops; but I think naval Officers will adduce many excellent reasons against cumbering the decks of men-of-war with soldiers during time of war, and when there will be a possibility of encountering a hostile fleet. There remain our naval transports, but wars break out suddenly now-a-days, and if hostilities were to be unexpectedly declared during the relief season, a great number of our largest troop-ships would probably be at sea conveying regiments to and from India. Besides the Indian transports, I find only eight or nine troop-ships in the Navy lists. Many of these would probably also be absent, so that we might very possibly have only two or three troop-ships left for our immediate use. I think, after Colonel Chesney's lecture in this theatre the other day, the Duke of Cambridge made some remarks on the great difficulty attending the transport question. I think, therefore, in a discussion "on the strategic importance of our harbours both for defensive and offensive operations," the question of transport is one which merits consideration. If our transport arrangements are in such a state as to cause us to feel no uneasiness as to our ability to move large bodies of troops by sea, even if called upon to do so unexpectedly, I apologise for taking up your time by the few remarks I have made.

Colonel ALCOCK: In corroboration of what Captain Needham has said, it may be in the remembrance of some of the gentlemen here who were present during the discussion on the possibilities of an invasion, that one very important point brought forward was, that at Hamburg and Bremen there are numbers of magnificent steamers perfectly adapted to the very purpose of invasion, with an army at their back organised for that purpose.

General COLLINSON: The first thing I shall say, Sir, in reply, is to express my great gratification that this paper has produced such an interesting discussion. And I think I may congratulate this Institution that, although perhaps the number of speakers has been small compared with what the importance of the subject really demands, still the value of the individuals and of the expressions they have made use of is so great, that we may compare it to the fleets and guns we have been talking of, comparatively few in number but so powerful that I think they will go through the country with great effect. I should wish to recapitulate a little the questions I have put before the meeting, touching upon the different points that the different speakers have mentioned. First of all, I should like to say a word upon the subject that was raised at the last discussion—Filey Harbour. I did not wish to enter into any discussion upon any particular harbour, or to make any comparison between the merits of one harbour and another; but I should like, as the question was raised, just to say that I arrived at certain conclusions with respect to the advantages of Dover from strategic considerations entirely founded upon the importance of keeping our home fleet concentrated in war time. I do not undervalue at all the importance of having a harbour upon the north-east coast, not only for war purposes, but for the shelter of our commercial trade in time of peace. I confess I think it is perhaps more important in this latter respect than for war purposes, but I am quite prepared, as I said in my paper, to affirm that for coaling purposes in time of war for our war fleet, and for the shelter of our cruisers, it is absolutely necessary that we should have some harbour somewhere or another on that north-east coast. Captain Steward asked some question about the force of a navy that would probably be required. I am afraid I am not myself prepared to give any definite answer to that question; but we had, after he spoke, the very great authority of Mr. Reed, stating that the British fleet cannot be considered as being in a condition at the present to be a match for combinations that might be made between foreign fleets; and therefore that shows we must be prepared to supplement our fleet with other means of defence. I am very glad to have the high authority of Mr. Reed to confirm the general principles that I wish to lay down in my paper, viz., that it is most important that we should put the coast of England into as thorough a state of defence as possible by local means, whether by sea or by land. By local means, so as to free our great main forces for employment in the more important duty of attacking the enemy; and we must consider, as I said just now, that the British fleet is not so very much superior to other fleets in the world that we shall not be obliged to be very careful upon the subject of its disposition and management. I do not know that there is any other point raised by gentlemen who have spoken to-night that I wish to make any remarks upon, because they confirm generally my views, although, perhaps, upon certain points of detail we may not be agreed, still, upon the whole, they are so far in accord with them, that I think it will be felt by all people who read the paper and the discussion that there is an agreement between naval and military men about the importance of increasing the defences that we have been discussing to-night. In my paper, I purposely avoided going into details about the different harbours, first, because I did not think it right to discuss publicly the specialities of each of our military harbours, but mainly because I wanted to raise the subject which we had under discussion from a mere comparison of particular local questions to what I must consider as a higher sphere, the general disposition of our strategical positions upon the sea. That is a subject which I think now requires re-consideration, as General Wilmot has observed. The arguments for a fresh consideration are these:—First, that there has been an alteration in maritime warfare caused by steam, and, I may say, by iron; and, secondly, that there are new and peculiar advantages in war arising from these to England especially. The alterations which appear to me likely to arise in maritime warfare are that there would probably be an increase in the size of what I suppose we must still

call line-of-battle ships, and apparently, as a consequence of that, that there will probably be a decrease in their numbers, so that war fleets will tend more and more to become composed of a greater number of swift and unarmoured cruisers and a smaller number of very powerful ironclads. That gives rise incidentally to another question that I will not discuss, namely, the advisability of keeping these costly ironclads in reserve during peace, and using for ordinary purposes unarmoured vessels. Then again, this change of fleets, if it does occur at all, will occur more in foreign nations than in England, for this double reason, that foreign nations cannot afford so many costly ironclads, and that the vulnerable surface of England, as Captain Grivel, of the French navy aptly calls it, that is to say, our sea commerce, can best be attacked by cruisers. And then again, this same change in fleets would lead to strategical combinations of inferior fleets opposed to us in order to take at a disadvantage the superior fleet of England or to effect a landing on our territory; and steam, I consider, gives an advantage to the enemy in making such a combination. Then the great ironclads of England having so greatly an extended line of ocean to defend against this new power of attack, will also, no doubt, be more concentrated each in the scene of operations allotted to it, and hence the necessity of increasing the number of shelter harbours and coal depôts each in good strategical positions as bases or centres of the area of operation, and England being in respect of her commerce always on the defence, requires many such centres; while the enemy, being on the offensive, can choose his own line of attack and prepare accordingly. I wish to say a word on the subject of the plan of shelter harbours, as that question has also been touched upon; and I will repeat what I consider to be the indispensable requirements of a good military harbour in these days—that it should have smooth deep water alongside a wharf with security from an enemy, and that neither of these requisites can be obtained thoroughly without small openings. For smooth water a small opening is a necessity. For security against an attack by night, there is nothing like a material obstacle across the entrance. Though guns and torpedoes are powerful weapons, and are likely to be more powerful, I am still somewhat inclined to agree with Admiral Porter (I think it was), of the United States navy, that they cannot be depended upon for stopping a bold seaman. There is another advantage in having smooth water in a military harbour, that the vessels can be packed much closer. War vessels lying in an open harbour require some 20 acres to each vessel. If smooth water was certain inside the harbour, surely some arrangement could be possible to place quite effectively at least five times as many in the same space. But the great advantage of smooth water is the saving of time; and time, as I said before, will be the essence of naval operations in future. A sailing-vessel, refitting in an open harbour, is something like a coach changing horses at a road-side inn; a steamer loading at a wharf is like a train watering at a station. With respect to the new and special power which I consider is now placed in the hands of England, or, as I will express it in the more happy terms of Captain Hoseason, the proper utilisation of our land and sea forces, the making use of the extraordinary power we possess now of producing steamers, and the command we have on the sea to make our little army do the work of, and keep well employed, one of the large Continental armies properly employed, I believe this power would put England very much in the position of being the peace officer of the world; but, as Captain Needham has very properly said, to effect this, requires more elaborate arrangements, especially as regards transport. In thanking you for listening to my remarks, and thanking those gentlemen who have added so much to the interest of this discussion, I will express the hope that this subject will be again and again discussed here. For, as I said at the commencement of my paper, I believe the people of England are really becoming aroused to the perception that war is a matter that must be considered and prepared for, if we want peace; and I believe the discussions here are of very great assistance to the nation in arriving at opinions as to the proper preparations to make, and I feel sure that when the people of England have resolved to act in war-matters, the same ingenuity, skill, and energy that they have shown in gaining the splendid empire we possess, they will also show in maintaining its interests unimpaired against any enemy.

The CHAIRMAN: Gentlemen, I am quite sure that we all feel grateful to General Collinson for the admirable paper he has put before us. I cannot help expressing

in passing, my regret personally—and I am sure that all who know General Collinson and his abilities will join me in that regret—that we should lately have lost from the public service, by his retirement, an Officer who is capable of taking so broad a view as he does, of the requirements of the British Empire in matters relating to its defence. In addition to the very interesting observations of General Collinson in his paper, we have been favoured with many important observations by other gentlemen well capable of forming an opinion on the question before us.

Maritime warfare must necessarily first depend upon ships. We must have cruisers to protect the lines of commerce which you see depicted on this chart, and I look upon it as a very good suggestion of Mr. Reed, that the great ocean steamships on our lines of passenger traffic should be provided with the means of carrying guns, so that they might be armed with a small number of pieces of ordnance, and in conjunction with such vessels as the "Inconstant," might aid in convoying vessels on those lines of commerce. It is necessary, as has been pointed out by the Lecturer, that our ships should be provided with coaling stations at intervals upon the lines of transit, and these stations should certainly be protected against occupation or attack by an enemy's ships. As General Collinson justly observes, if we have coaling stations and do not protect them, we provide fuel for the enemy, as well as for ourselves; during the absence of our cruisers or squadrons, he would be able to help himself to our coal. It is therefore most important that not only Malta and Gibraltar, Halifax and Bermuda should be thoroughly protected, but that places like Port Royal in Jamaica, Simon's Bay at the Cape, some point in Ceylon, Aden, Bombay, Singapore, King George's Sound in Australia, and some other places, should be properly defended as coaling stations for the squadrons and cruisers which are to protect our commerce. For the defence of our shores at home, conveniently situated and well-defended harbours are necessary for sheltering and coaling our squadrons. These harbours, in fact, become foci of refuge and action for our fleet. Where nature has not provided such harbours, they should be constructed artificially. We have fine strategic harbours at Cork, Pembroke, Plymouth, Portland, and Portsmouth, and of these the harbours of Plymouth Sound and Portland are formed by artificial breakwaters. Dover is a half-completed artificial harbour, of which only one arm has as yet been constructed. It is a most important position for naval defence, and I should much like to see the harbour there completed. We have had a good deal of thought given in this discussion as to whether the harbour at Dover should be completed before Filey Bay is undertaken. The fact is, however, that we want harbours at both those points. Dover has naturally the priority of consideration, because of its importance for international communication. We have already fortified harbours on the southern coast, and we want to turn the corner, so we should like now to go on with Dover. Filey Bay, if funds will permit, may follow at some future day. With reference to Mr. Reed's observation as to the defence of the coast by means of volunteer artillery, I think that it is most important to apply the services of volunteer artillery to the manning of guns for the defence of our ports. The Volunteers should be told off, each body to its own particular harbour, or to its own part of the coast. We should then find that they would take great interest in the work they had to perform; and such an organisation would be most valuable for the defence of our coast. As regards his further proposal for the preparation of frames of gunboats, the suggestion is no doubt worthy of consideration; but it seems to me that the remark made by Captain Ardagh with reference to the defence of ports by means of land batteries, should be taken into consideration in conjunction with this proposal. In each case we must consider carefully whether the circumstances are such that we can best provide for the defence of our harbours and our coast by works and batteries on land, or by armed vessels afloat. I would not dogmatically lay down any rule that gunboats are better than fortifications, or that fortifications are better than gunboats. In some cases, one will be best, in some cases, the other; in some cases we require both. In some few cases, fortifications will not help us at all, and floating defences must be adopted. We should therefore consider carefully in what positions each element is required, and deal with the problem according to the merits of the case. There is one point especially referred to in General Collinson's paper, which I have not yet touched upon, that is, the question of our undertaking what is termed "offensive warfare." In the abstract,

there can be no doubt that it is a good principle to provide for defence by assuming the offensive; but I confess, when I know the difficulty of finding troops for the various duties our Army has to perform in different parts of the world, I do not think we can hope to put into the steam transports to which General Collinson refers, any force that would produce an appreciable effect against the great hosts the Continental nations can bring into the field. If we had a law of conscription in this country—but I never expect that this country will ever adopt such a plan for raising its forces—no doubt it would be desirable to adopt the offensive plan which is advocated. But whatever may be the differences of opinion on this point, there can be no doubt as to the necessity of making arrangements by fortified harbours, and by local means of defence, to set our fleet free for the protection of our commerce, and for offensive operations *at sea* against the enemy, in whatever quarter he may show himself.

Gentlemen, you will join with me in giving our best thanks to General Collinson for the admirable paper he has read to us.

Evening Meeting.

Monday, May 4th, 1874.

VICE-ADMIRAL A. P. RYDER in the Chair.

NAMES of MEMBERS who joined the Institution between the 21st of April and 4th May, 1874.

LIFE.

Richmond, His Grace the Duke of, K.G., &c., late Royal Horse Guards.
Trevelyan, W. R., Captain, Bombay Staff Corps.

ANNUAL.

Hutchinson, W. L., Inspector of Cape Frontier M. Police.
O'Connor, J. J., Inspector of Cape Frontier M. Police.
Miller, Thomas E., Lieut., R.N.
Coleman, W. F. G., Captain, late Royal Dragoons.
James, W. C., Sub-Lieut., 2nd R. N. B. Dragoons.
Clarke, P. P. D., Captain, h.-p., 64th Regiment.
Pierson, W. Henry, Captain, R.E.
Champion, P. R., Lieut., R.M.L. Infantry.
Marriott, Wm. H., Lieut., 36th Regt.
Jeffreys, E. F., Lieut., R.N.
Festing, Sir Francis W., C.B., K.C.M.G., Colonel, R.M.A.

ON A NEW BOOK OF STELLAR AZIMUTH TABLES, AND ON A NEWLY INVENTED ILLUMINATED STELLAR AZIMUTH COMPASS.

By WM. S. CROUDACE.

IN this age of iron ships and iron steamers, and having regard to the very serious loss of life and property at sea during the past year, it becomes more and more necessary that Commanders of those ships should possess every possible means of checking the compasses by constant reference to the heavenly bodies both by day and night, whenever such observations are available; for notwithstanding the progress that has been made in the knowledge of the magnetism of iron ships, as affecting the compass, and the accuracy with which the deviation tables are now calculated, I think I am nevertheless safe in stating, that no Commander would unreservedly place confidence in them, in preference to an azimuth of the sun or a star.

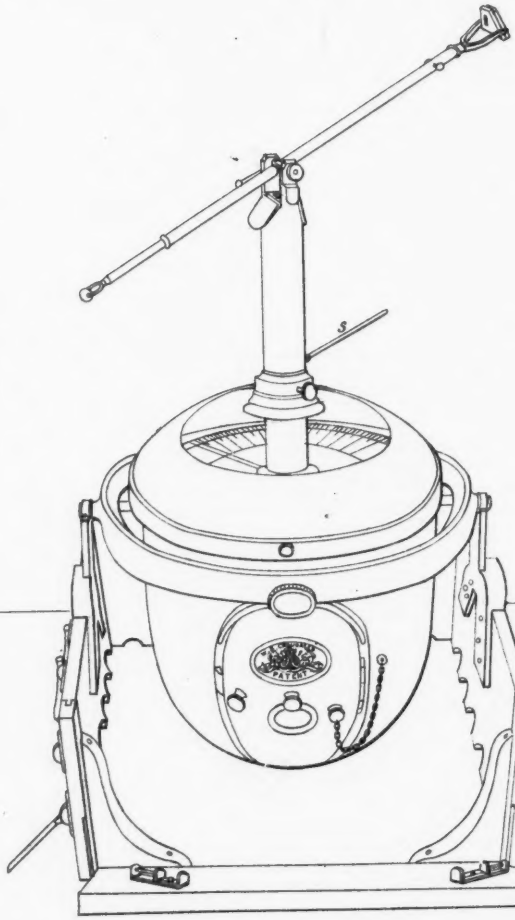
As a Commander of 27 years' standing, and having commanded iron ships and steamers since 1855 in the merchant service, I can bear testimony to the great advantage of having the sun's azimuths calculated and put into a tabulated form, requiring no altitude to be taken

when correcting the ship's course, for it often happens at sea in cloudy weather, or in fogs, when the horizon is invisible, that the sun's disc or its halo may be seen sufficiently well defined to obtain a bearing when the altitude cannot be observed, and when consequently the azimuth could not be calculated. It has, moreover, frequently occurred to me, that as the sun's azimuth tables were so valuable under such circumstances, why not have similar tables of some of the principal fixed stars, to fill up the *hiatus* of a long winter's night, and provide the mariner with an equally ready means of checking the course in the absence of the sun; for, what I have advanced respecting the invisibility of the horizon in the day time, and the impossibility of obtaining an altitude, very often applies with much more force during the night.

Since my retirement from the service, the importance of such a provision for night use at sea has become more apparent than ever; such recent losses as the steamers "Parnassus" and "Singapore" near to Cape Guardafui, and the "Atlantic" and "City of Washington," on the other side of the Atlantic Ocean, with many more nearer home, might probably have been averted, had the Commanders been furnished with such means. These considerations, coupled with leisure time, and a feeling that something might be done to aid in diminishing such disasters, which almost invariably occur in the night time, have ultimately resulted in the production of the stellar azimuth tables recently published by me, and now before the nautical public, together with some other easy formularies for finding a ship's position by the stars and the sun, and also in the production of the Illuminated Stellar Azimuth Compass specially invented to accompany the stellar azimuth tables, and which by the kind permission of the Council of this Institution I am allowed to exhibit and describe to you this evening.

In the tables above mentioned, the azimuths of three stars have been calculated for every night during the year with but few exceptions, thus giving the mariner a three-fold opportunity of checking his course in the easiest possible manner, and without having to leave the deck; and as the motion of the stars in right ascension and declination is very slow, the azimuths (as given in the tables) will not be sensibly affected for forty or fifty years to come. They are available from the equator to 62° of latitude north and south. In latitudes exceeding 30° north or south, the azimuths are calculated for each point of the compass from the time of the star's rising, or becoming visible after night-fall, until its setting, or until dawn, as the case may be. From the equator to latitude 25° north or south, the azimuths are calculated to half, and occasionally quarter points for a time after rising, and a similar time before setting; and many cases will be found in the tables for the lower latitudes, and in the vicinity of the equator, in which the stars remain from two to five hours on the same bearing, or so near to it that for all practical purposes they may be considered so. Such bearings must prove of great value to the navigator in those regions where they are applicable, for, during these intervals of time, the star may be regarded as a fixed point in the heavens, requiring no calculation beyond a knowledge of the latitude, for correcting or checking the course steered. Each table has a difference-column attached to it, showing the

GROUDACE'S STELLAR AZIMUTH COMPASS.



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time that a star takes to move from one bearing to the next, so that, whenever an intermediate bearing may be required, a simple inspection of that column will enable any one to compute mentally the star's azimuth corresponding to the time required. Objections have been raised to the azimuths being calculated only to points, instead of to degrees; but with equal reason we might object to the elements in the nautical almanac, such for instance as the sun's right ascension and declination that are calculated for every twenty-four hours only, and ask to have them given for every hour, or that the lunar distances should be calculated for every ten minutes instead of for every three hours; but such a course would only swell out a book to most undue proportions without adding to its real usefulness. With these remarks respecting the stellar azimuth tables, I will now pass on to the Illuminated Stellar Azimuth Compass itself, of which the one now before you is a full-sized model (see Plate).

In carrying out this invention, I apply on the outer circumference of the compass card a toothed wheel or rack, into which gear two pinion-wheels placed within the compass bowl. The axles of these pinion-wheels pass through the necks of the gimbals supporting the compass, and have milled heads at their outer ends. By turning these milled heads the compass-card can be turned in a steady and uniform manner without disturbing the perpendicularity of the compass; and this arrangement allows of the compass-card being enclosed under a glass cover or dome to protect it from the effect of rain or spray. In the bowl of the compass I place a lamp for illuminating the compass-card, which I make of frosted glass or mica, thus enabling observations to be taken and read off during the night without the aid of an outside lamp. The heated air and products of combustion from the lamp are carried off through the centre of the compass-card and up through the standard surmounting the dome; the indicator for registering the bearings or azimuths is fitted to the base of this standard, and the pointer which is fixed on a joint at the top of the standard is provided at its outer end with a mirror, and at its inner end with a spherical lens, and both are illuminated by the rays of light from the lamp passing through the compass-card and the glass dome.

The apparatus for lighting the lamp consists of a metal tube split and flattened at the outer end, the inner surface of the flattened part being roughened to form a friction surface. A match-holder is provided to fit into this friction-tube.

In order fully to appreciate this invention, we have only to call to mind the difficulty that is often experienced in obtaining a ready and correct bearing of the stars, or of a light on the coast during the night. The binnacle, or other permanently fixed compass, can never be placed so as to command an uninterrupted view of the object, or of the horizon on every point, and recourse must be had to a portable dumb compass, or other expedient, and a lamp to enable the observer to read off the bearings. But this mode is open to objections, for often before the lamp can be brought into position, the opportunity has passed, and the rays from it render it impossible to distinguish surrounding objects for some time afterwards. In making use of the illuminated stellar azimuth

compass, these objections will be entirely obviated, as it is admirably adapted for observing the bearings of the stars from the stellar azimuth tables, or for taking correct bearings of lights on the coast. Being furnished with a lamp within the bowl, and a match-lighter (by means of which it can be lighted on deck instantly, or on the bridge of a steamer, even in a gale of wind, never requiring to be taken below to the lamp-room), and when lighted, no ordinary wind can extinguish it, having also a transparent compass-card offering a subdued light, free from all dazzling effect to the eye, and the pointer being illuminated at both ends, bearings may be taken with the utmost accuracy on the darkest night. If necessary, at a trifling expense of oil, the lamp can be kept alight throughout the night ready for observations at any moment. Indeed, the stellar azimuth tables can scarcely be accounted complete without the use of this compass, for everything depends at times upon taking the azimuth quickly, such as on cloudy nights, when the objects are only occasionally visible. In such cases, it will be found all that can be desired. The light from it, passing through the small screened window fitted in the door of the bowl, serves to read off the azimuth from the tables, instantly the indicator can be set to the given azimuth on the compass-dial, and the observation taken in about a minute. Or the following method may be adopted, even with greater certainty, to find the true course on a cloudy night, when only occasional glimpses of the stars are obtainable. Suppose a ship to be in latitude 49° to 50° north on the 10th January, and the apparent time to be 11 h. 15 m., a reference to the tables in Vol. I shows that the star "Aldebaran" bears S. 4 W. at 10 h. 55 m.; we accordingly set the indicator at this bearing on the compass-dial, and watch for a glimpse of the star. Let us suppose, now, that a glimpse has been obtained, and an accurate bearing observed, immediately afterwards we refer to the watch, and find it is 11 h. 15 m., and on looking at the true course registered on the compass-dial, we find it is N. 6 E.; we now refer to the difference-column in the table, and find that the star moves from S. 4 W. to S. 5 W. in 38 minutes, and from 10 h. 55 m. (the time at which the star bore S. 4 W.) to 11 h. 15 m. (the time of the observation), the interval is 20 minutes. We may, therefore, for all practical purposes, safely assume that the true bearing of the star at the instant of the observation was S. $4\frac{1}{2}$ W., and by applying this correction of half a point to the course shown on the compass-dial, we have N. $6\frac{1}{2}$ E. as the actual true course when the observation was snatched.

A previous knowledge of the stars is not absolutely necessary to a beginner in the use of this compass and the tables, for, as it is supposed that every Commander knows the true course his ship is making within at least half a point of the truth, he has only to set the compass with its lubber's point in a line with the ship's keel, then to screw round the compass-card until it represents the ship's true course, to take out the star's azimuth from the tables, and set the indicator of the compass to the given azimuth, and the pointer will then be directed to that part of the heavens where the star is shining, or at least sufficiently near so as to distinguish it from any other, more particularly as none of the stars selected for the azimuths are below the second magnitude, they there-

ORDNANCE NIGHT SIGHT VANE.

Fig. 1.

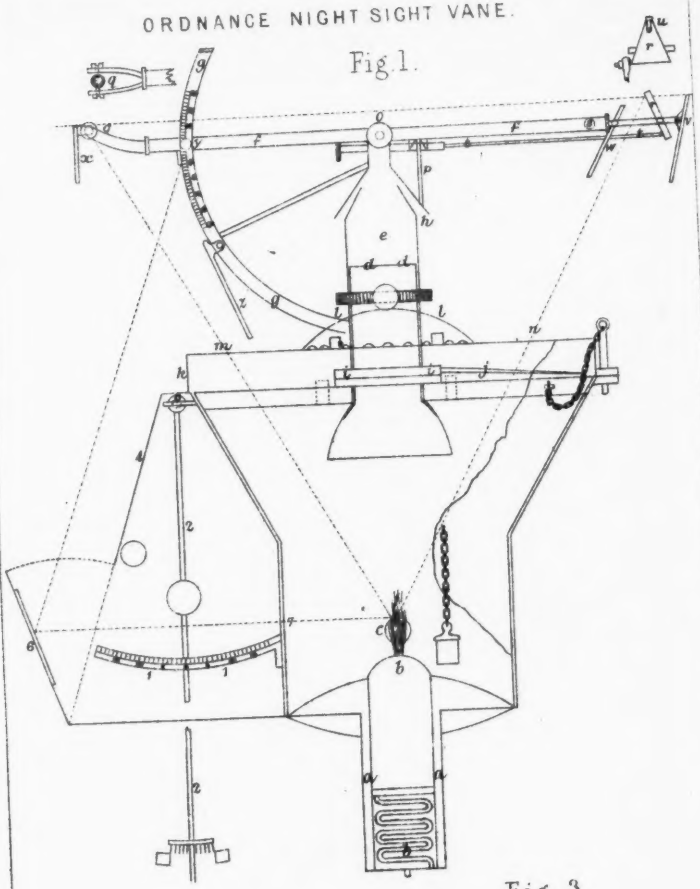


Fig. 3.

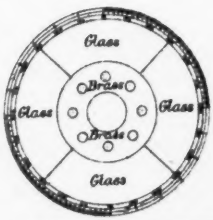
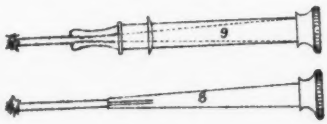


Fig. 2.



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fore cannot well be mistaken, and after a little practice they will become quite familiar to the eye.

Apart from its superiority over any other compass for night observations, it is equally well adapted for taking the sun's azimuths in any weather, for, provided the sun's disc be only faintly discernible through the fog or clouds, a very accurate bearing may be obtained by means of the pointer, and the true course found with great precision; and on the other hand, as the compass is also furnished with a movable style (*s*) to be used with bright sunshine, the course can be found with equal facility as by any other dumb compass ordinarily used for day observations.

In concluding my lecture on this subject, I by no means wish it to be understood that any dumb compass or azimuth tables will enable us to dispense with the deviation tables; these appliances must, in fact, only be regarded as auxiliaries, for we can no more dispense with the deviation tables than we can with the variation of the compass. But what I desire to be distinctly understood respecting these auxiliaries in the first place is, their great usefulness and simplicity as checks, at all times, to the deviation tables, more particularly on board ships returning from distant stations, or from long voyages, with little or no confidence remaining in their tables, furnished, perhaps, twelve months before; and lastly, the extreme accuracy with which cross-bearings of lights during the night may be observed by means of the illuminated compass, free from all glare and dazzling effect to the eye, which advantage in itself, even supposing it to possess no other merit, must ultimately obtain for it a place on board most ships.

Touching the deviation tables, so far as the merchant marine is concerned, I think the form of them might be simplified and made much more suitable for working on true meridian charts, and I would have all charts published with only the true meridians marked upon them. In swinging the ship, I would have the whole amount of error on each true point, arising from variation and deviation, given in one sum with an accompanying note on the margin of the deviation-card of the absolute amount of the variation of the compass due to the place where the ship had been swung; then any change of variation due to change of place could easily be applied in the same manner that the variation is applied in wooden ships to find the true course. The perplexity arising from the proper application of deviation, variation, and heel of the ship is very embarrassing when carried into actual practice on board iron vessels.

ORDNANCE NIGHT-SIGHT VANE.

The next subject to which I beg to draw your attention is the "Ordnance Night-Sight Vane." In the first place I will describe its construction, and afterwards endeavour to explain its use for military and naval purposes in laying guns in the night time.

The upper part of the body of the instrument (Fig. 1) is conically shaped, the lower half is cylindrical; or the body may be entirely conical. Projecting from the bottom is a square-shaped slot (*a*) for

those vanes intended to be placed in a corresponding socket on the cascabel or breach of a gun. On those intended to be used as object-finders, collimators, or directors, this slot is made perfectly round, in order that the instrument may be turned in any direction. Within this slot, a tube and candle (*b*) are placed; and the bottom of the instrument is bored out in the centre, to allow the tube and candle to be inserted, so as to reach just within its interior. On the right hand side of the lower half is a small round hole (*c*), fitted with a plug and chain; through this hole, and by means of an accompanying friction-tube, shown in Fig. 2, the candle is lighted within, in any weather, either wind or rain, without the least sign of light being visible in any direction at 10 yards distance.

The circular dial (Fig. 3), about half size, is marked round its circumference to every degree. The arrangement of the degrees in the four quadrants will be readily understood without further explanation. The central part of this dial is made of brass, bored out and perforated for the passage of smoke and heated air. From the outer rim of the central brass part to the circumference of the dial itself, frosted glass or mica is fitted into each quadrant, so as to give a supply of light when reading off the degrees on its circumference. The dial is firmly fixed to the body of the instrument by means of two set screws.

Fitting over the chimney (*d*), with its lower part close down to the collar on the chimney, and exactly in the axis of the instrument, is a hollow standard (*e*), for supporting the pointer (*f*), and the double quadrant (*g*), fixed to its rear. This standard also forms the upper portion of the chimney, the smoke and products of combustion passing out at the sloped vents (*h*), near its top immediately below the pointer. To the collar (*i*), fitted round the base of this standard, is affixed the indicator (*j*), by means of which the angles taken by the instrument are read off. Affixed to the standard, a little above the indicator, is a metal cover (*k*), which entirely closes the dial from view, and shuts out the rays of light that might otherwise dazzle the eyes. This cover is also perforated round the standard, and the light from these holes covered over by a raised cowl-shaped screen (*l*). On the metal cover (*k*), exactly in the plane of the pointer (*f*), are two triangular apertures (*mn*), which can be opened or shut at pleasure. Through these apertures the angles are read off on the dial, and light admitted to the extreme ends of the pointer.

The pointer (*f*) is fitted on the top of the standard with a set screw (*o*), by means of which it can be fixed at any angle; a hinged stop (*p*) is also fixed in front of the standard under the pointer, which, when brought to rest upon it, represents zero of the quadrant on the rear of the standard. On the inner extremity of the pointer, a spherical lens (*q*) is fitted. This lens collects the rays of light passing through the aperture (*m*), and forms the inner illuminated sight when taking aim. On the outer extremity of the pointer is a hinged triangular mirror (*r*), which in like manner collects the light through the aperture (*n*). This mirror is adjustable by means of set screws (*s*) on the pointer, and an incidence rod (*t*) attached to one corner of its base and to the standard. The object of this rod is to control the reflected light obtained at the point

of incidence, through the slit screen (*u*) attached to it, so that it may always be thrown along the line of the pointer, in the exact direction of the spherical lens at its inner extremity, at whatever angle it may be placed, which thus insures the outer illuminated sight when taking aim. The screen (*v*) at the back of the mirror is intended to shut out reflected light when viewed in front. The screen (*w*), excludes reflected light from the eye when taking aim; and the shield-shaped screen (*x*), in front of the spherical lens, is to protect the eye in like manner from the reflected light issuing from the aperture (*m*) beneath.

The double quadrant (*g*) fitted on the rear of the standard, and between which the pointer travels, serves to mark the angles of elevation or depression; a set screw (*y*) is also fitted to the pointer, in order to secure those angles immediately. This quadrant has a range of 20° elevation, and 20° depression; and at the bottom of it a hinged screen (*z*) is fitted to shut out reflected light from the back of the quadrant.

At the rear of the body of the instrument is another quadrant (1), and pendulum (2). This quadrant shows at a glance the exact elevation or depression of the gun, as well as its deflection, the pendulum being hung on a gimballed joint (3), admitting of lateral and front and back motion at the same time. This quadrant and pendulum are enclosed in a casing; and on the back of this casing is a double-hinged door (6), having a mirror fixed on its inside. When this door is opened, the light from the candle, passing through a small square of glass (7), is caught in the mirror, and can be reflected to the upper quadrant and pointer, thus enabling the observer to read off the angles of elevation, &c., thereon registered, without the aid of another lamp, at the same instant that the angles on the lower quadrant are being read off.

To light the candle, an ordinary match that will ignite when rubbed on a rough surface is inserted into the slit end of the match-holder (8, Fig. 2). The holder and match are then inserted into the friction-tube (9), the plug is withdrawn from the hole (*c*) in the side of the instrument, and the lighting apparatus is inserted into the hole; the door (6) on the back of the casing is then opened, the match and holder are pushed smartly through the friction tube, thereby igniting the match inside the lamp, and the candle is lighted by directing the match by means of the small square of glass (7) in the rear of the lamp.

Having thus described the various parts of the instrument, we now proceed to make a few remarks on its use.

Assuming that a square socket has been cut in the cascabel, or fitted in a convenient position on the breech of a gun, so that when the "Ordnance Night-Sight Vane" is dropped into it, the pointer when set at zero on the arc attached to the rear of the standard will represent the axis of the gun; the quadrant on the rear of the body of the instrument will at once show the angle of elevation or depression and deflection; and, as the instrument is now attached to the gun, if it be wanted to fire at an object with an elevation of 5°, the mere moving of the elevation screw will be registered by the pendulum and

quadrant on the rear of the vane, and the gun can be set with the greatest accuracy. If the object to be fired at be visible, then for every degree the gun has to be *elevated* or *depressed* the pointer must in like manner be moved in a contrary direction with the pendulum, *i.e.*, *depressed* or *elevated* to the same degree; and, on looking along the illuminated line of sight on the pointer, the object can be brought on with the line of fire as accurately as in the day time.

The "Ordnance Night-Sight Vane" is particularly adapted for use as an object-finder or collimator, and when so used it can be mounted on a solid box or a tripod, and, as previously mentioned, the slot must be perfectly round, so as to fit into an adjustable ball-cup on the tripod, in order that it may be turned round in any direction.

Having affixed the vane in the cup, and adjusted it exactly perpendicular by means of the pendulum and quadrant on its rear, it should be placed either right in the rear of the gun or at an angle of 90° on either side of it, as being the most eligible for facilitating the reading off and transmission of angles from one to the other. These positions are easily obtained by setting the sights of the vane attached to the gun at these points, and by observing their bearings from each other, the object-finder and the instrument on the gun can readily be placed in the same line. If it is decided to take up a position in the rear of a gun, the zero points of the two instruments should be brought in the same line of sight, and they will then be ready for immediate operations. If we now suppose a light to be suddenly observed from the enemy's position, or the flash of a gun from a masked battery, or the position of a body of troops disclosed by throwing up a star shell, the person in charge of the gun or the instrument, or both of them, simultaneously fix the angle of position; if both instruments succeed in effecting this, there will be greater confidence in the angle obtained, especially if they be found to correspond exactly, and at any distance exceeding a quarter of a mile the parallax will be very small indeed. Suppose that angle to have been 30° on the right front quadrant of the instruments, the light or flash we now suppose to have disappeared, but as we know the angle of position from the line of fire, in which the gun and the collimator are placed, we can easily train the gun round exactly on that point in the following manner, viz.:—The person in charge of the collimator sets the illuminated pointer back to zero, at the same time that the person in charge of the instrument on the gun sets his pointer at 30° on the left front quadrant; the order is now given to trail left until the two lights of the instrument on the gun are brought exactly in line with the sights on the collimator; this done, the axis of the gun or line of fire will be in the exact horizontal point of the light or flash when observed. And as the collimator is supposed to be placed perpendicular, if its pointer had to be elevated or depressed when observing the light, &c., the upper quadrant of the instrument will register the amount of elevation or depression necessary to be given to the gun in order to fire point blank at the object.

If, on the other hand, it be decided to take up a position at 90° to the right of the gun, in that case we fix the collimator with its *rear* zero point in a line with and nearest to the pointer on the gun,

placed at 90° for the following reasons, viz. :—as the door for inspection of the lower quadrant and the plug-hole for lighting the candle open from its right side, they can thus be made use of without displaying light to the enemy; and at the same time the angles registered by the collimator are transferred to the instrument on the gun without having recourse to subtraction or addition, and the risk of reading or setting off wrong angles thereby lessened, the axis line of the gun or zero of the instrument attached to it being represented by 90° on the collimator. But if the position taken up by the collimator be at 90° left of the gun, in that case, and in order to keep the light from the enemy we place the collimator with its *front* zero point towards the gun, and the angles will be read off in the reverse order of the preceding case. With these premises established, we obtain the following tabulated form for setting a gun at any angle.

Collimator placed in the rear of the Gun, with the zero points of the two instruments in the same horizontal line.

Angle of object observed from the Collimator.	Angle at which to set the instrument on the Gun.
15° Right front quadrant.	15° Left front quadrant, and trail gun to left.
45° ,,	45° ,, ,,
90° ,,	90° ,, ,,
75° Right rear quadrant.	75° Left rear quadrant, ,,
45° ,,	45° ,, ,,
0° rear	0° rear and trail left or right.
15° Left front quadrant.	15° Right front quadrant, and trail right.
45° ,,	45° ,, ,,
90° ,,	90° ,, ,,
75° Left rear quadrant.	75° Right rear quadrant, ,,
45° ,,	45° ,, ,,
0° rear	0° rear and trail right or left.

And so on for any of the intermediate degrees.

Collimator placed at 90° right of the Gun, with its rear zero point nearest to and in same horizontal line with 90° of the Gun.

Angle of object observed from the Collimator.	Angle at which to set the instrument on the Gun.
75° Right front quadrant.	75° Left rear quadrant, and trail left.
45° "	45° " "
0° "	0° rear "
15° Right rear quadrant.	15° Right rear quadrant, "
45° "	45° " "
75° "	75° " "
90° rear	90° " and trail left or right.
75° Left front quadrant.	75° Left front quadrant, and trail right.
45° "	45° " "
0° "	0° front "
15° Left rear quadrant.	15° Right front quadrant, "
45° "	45° " "
75° "	75° " "
90° rear	90° " and trail left or right.

And so on for any of the intermediate degrees.

Collimator placed at 90° left of the Gun, with its front zero point nearest to and in same horizontal line with 90° of the Gun.

Angle of object observed from the Collimator.	Angle at which to set the instrument on the Gun.
75° Right front quadrant.	75° Right front quadrant, and trail left.
45° "	45° " "
0° "	0° front "
15° Right rear quadrant.	15° Left front quadrant. "
45° "	42° " "
75° "	75° " "
90° rear	90° " and trail left or right.
75° Left front quadrant.	75° Right rear quadrant, and trail right.
45° "	45° " "
0° "	0° rear "
15° Left rear quadrant.	15° Left rear quadrant. "
45° "	45° " "
75° "	75° " "
90° "	90° " and trail left or right.

And so on for any of the intermediate degrees.

When continuous firing at the same point is required (as the collimator is supposed to be fixed in its position), after each shot, the gun can be run up and take the same position from the collimator as before.

In reference to the foregoing rules, and in further explanation of the utility of the instrument for field purposes, if we suppose the object or light to have been observed from the collimator at an elevation of 3°, then, after the gun has been trailed round in the line of fire, it will next be necessary to obtain the angle of elevation, and this is the more necessary should the ground be at all uneven; in such a case, the mere act of examining the pendulum and quadrant on the rear of the instrument will show how the gun is placed. Say that the pendulum registers 2° depression, then it is clear we must move the gun in its axis 5°, in order to have the same angle of elevation, viz., 3°, as that registered on the collimator, before the gun will be point blank on the object; and if the distance be judged such as to require a trajectory of 2°, then the whole angle of elevation on the gun will be 5°.

It will at once be seen after consideration of the foregoing rules, that, in like manner, any other field piece, or an entire park of artillery can be brought in line; and in a very short time they could all be brought to bear on the same horizontal point.

In fortifications, this instrument can also be usefully employed in connection with ordnance mounted on platforms and racers, or turntables, the gun being brought to zero or centre line, and the object-finder fixed in the same horizontal point, in some desirable position for observation, any object at which it is required to fire can be watched and set on the object-finder, and the number of degrees registered from the zero-point can then be called out, and the gun trailed round to the same line of fire.

There are two special features in this invention which I think will be admitted as of great importance in night-firing: one of them consists in the simple and effective mode of re-lighting the candle after the gun has been fired, in the event of the concussion extinguishing it; the other consists in the accuracy and steadiness of the illuminated sights for taking aim, which is obtained without telescopic aid. Such aids we know are not desirable, for they cannot be made use of without affecting the pupil of the eye, and thereby unfitting it for a time afterwards to observe objects at a distance. Whereas, in using this instrument, the eye preserves its natural full force of penetration in the dark and its proper focus, as the glimmer from the sights, and the mellowed light from the dial, have no power to disturb the pupil of the eye or to disarrange the ordinary vision.

Objections have been raised to this instrument because of its inability to give the distance of the object to be fired at, and the consequent uncertain elevation in laying a gun so as to hit the object. I know of no single instrument capable of measuring horizontal distances even in the day time, much less so at night, but by making use of two or more of these instruments so as to establish a base line, and by taking the exact bearing of them from each other (which can be easily done by opening the plug holes, so as to display the lights), then by simultaneously observing the flash of an enemy's gun, &c., or a hostile vessel, from

the two instruments; the angles contained between the two extremes of the base line and the flash, or vessel, would readily give the distance by making use of the triangular distance-finder, whose base line had been previously set to correspond with the distance between the two instruments, as the two strings attached to the extremes of this base line, when extended so as to cut the given angles, would, when measured on the base line, give the distance sufficiently near for practical purposes in the night time. At all events, this is the nearest solution of the difficulty that I can suggest when time is of importance.

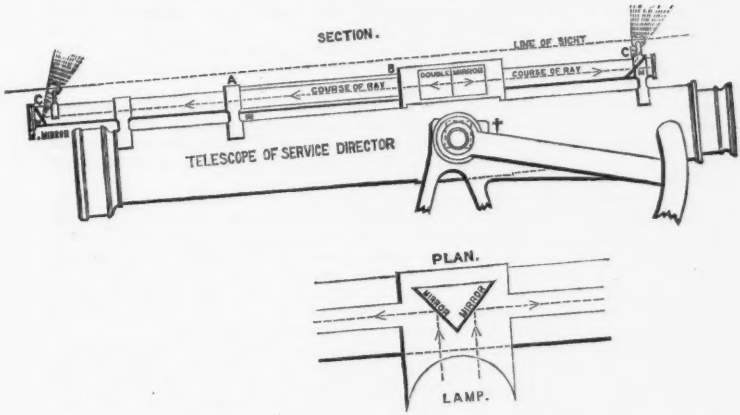
We will now explain its use for naval purposes, and endeavour to show that it can be made to do when employed as a night-director, exactly what is now done in the day time by the day-director. In order to obtain a greater radial distance between the sights, a long bar is attached to the foot of the instrument, having an upright double quadrant attached to the bar near to its outer end, instead of to the standard, the inner end of the pointer being lengthened so as to pass between the quadrants. In this case, instead of a pendulum, a moveable index is substituted, so as to form a dip sight, the light, by which the inner sight is obtained, instead of passing through the dial face of the instrument, is transmitted through the small window in its rear to a swing mirror at the outer end of the casing, which in turn throws the reflected light into the spherical lens. This mirror also serves to illumine the degrees on the upright quadrant, whilst at the same time the mirror fixed on the back of the quadrant serves to read off the angles on the hemicircle. To those conversant with the day-director, no further explanation is required to show what can be effected by this instrument in the dark.

In conclusion, this principle of illuminated sights may be equally well applied to the torpedo-director with slight modifications. For instance, a lamp with only one arm bearing a spherical lens and fitted with a round slot made to pivot where the telescope is placed for day practice, would give the inner night-sight. The outer sights around the circumference of the director, could be made to receive other lenses, and behind each lens a lamp could be placed having a small aperture on its top to illumine the lens, and thus obtain the outer night-sight.

Shortly after this lecture had been sent to be printed, I received a letter from Lieutenant Grenfell, senior Staff Officer on board Her Majesty's ship "Excellent," at Portsmouth, and this accompanying sketch, in which he describes, and exhibits on the drawing, a modification of my principle of the illuminated sights, adapted to the "Elliott New Service Night-Director." This modification enables us to dispense with the mirror forming the outer sight, and also the incidence rod, admits of a very free line of sight, and lessens the complicity of the parts. The modification is very ingenious, and for naval warfare a decided improvement on the instrument now before you. By this device, Lieutenant Grenfell obtains by means of the single lamp, the same result as proposed by me in the torpedo-director with two or more lamps.

NIGHT-SIGHT ATTACHED TO THE SERVICE DIRECTOR.

Elevation and Plan.



* This part of the tube is double, to enable a longer radius to be given, if desirable, by pulling out the smaller part. The radius can then be increased by the distance A, B.

† The lamp ships on to a small socket (sketched with dotted lines) placed in the axis of the telescope, and can be removed to illuminate the arc and dip sight.

The CHAIRMAN: Is your Stella Azimuth compass supplementary to the ordinary ship's compass?

Captain CROUDACE: It is. I have been surprised at my own observations taken with it to find how beautifully you could bring on the points of intersection, and by means of the lights and the very easy motion by which you can move the instrument and observe at the same time, you can cut a light extremely fine.

The CHAIRMAN: Have not you a report from a person who has used it? If so, it might be interesting to hear it read.

Captain CROUDACE: This is a certificate from a gentleman who has already had my books but not the compass. He says—"Dear Sir, I have tried your 'Stellar "'Azimuth Tables' on a voyage from London to Calcutta and back (*viâ* Suez), and "have found them so useful that I cannot speak too favourably of them.

"I consider them far superior to any 'Daylight' tables published, especially in "narrow waters, where the courses require to be altered frequently during the night, "as is the case in the Red Sea navigation. The compasses used to be a great source "of anxiety to me, but now they give me no uneasiness whatever, as I have the "courses checked frequently every watch, and a record of the error kept, and the "Officer on duty can always tell (knowing the true course he is required to steer) "if there is any change in the deviation, through local attraction or otherwise, and "report it, and the change can be allowed for at once.

"I have used the Tables with an ordinary dumb card, but have no doubt your "Stellar Azimuth Compass will make them still more valuable. Hoping your tables "will have a wide-spread circulation as they must have when they become known, "I am, yours very truly, CHARLES BARRIE, Master of steamship 'Duke of Argyle.'" The above is a large steamer of 3,000 tons, which sails out of London.

Captain BURGESS: What would be the cost of your stellar azimuth compass?

Captain CROUDACE: Ten guineas.

Captain L. F. JONES, R.N.: Does it not also apply for the sun?

Captain CROUDACE: Quite as well for the sun. You have only to turn the pointer up, and by the sun-book, make use of the movable style (*s*, Plate XII). These sun-tables are calculated exactly on the same principles as these are for the stars. They are calculated for the sun in order to obtain the angle without having to get an altitude. It is very important in the merchant service, where there are no more hands than are absolutely required, that you should be enabled to check your course without having to leave the deck. By this table for the sun, we can do so with the style alone; you set the azimuth to the sun as for the star.

Commander BRENT, R.N.: Do you find that motion affects your stellar azimuth compass more than the ordinary azimuth compass, the point seems so fine?

Captain CROUDACE: There is no difficulty at all, because you merely have to look over it; you do not look through it. The star may be assumed to be a little above the pointer, according to the elevation.

Commander BRENT: I think that this Stellar Azimuth Compass of yours will be of very great value to the ships in the Royal Navy from the fine bearings you can take by night, because you get a sight within a few seconds as delicately as possible. As to the Night-Sight Vane or Collimator, I have had the advantage of seeing it before, and I was very much struck with the ease with which you could get your sights on, and with the amount of information the instrument gives you altogether. You have everything under your hand. The small illuminated points do not blind the eye at all. I have looked through the instrument at a gas-lamp, for instance, I have also taken a very dark object, and I find you are able to get it quite distinctly. As to the light being extinguished from the concussion of firing on board ship, &c., I do not suppose that there is any light that will stand that; I do not think you will ever be able to get over that difficulty. But Captain Croudace has a very ingenious way of re-lighting this apparatus, so that, a match being fixed, you can re-light it at once. I am convinced that that, or some adaptation of it, is a thing that would be of great use to us in any night work we may have in future.

The CHAIRMAN: I will now ask you to allow me to thank Captain Croudace, in your name, for the very interesting paper that he has read to us. He has attempted to hit two blots which we have always found in our way in the Navy; the one, getting good stellar observations by night, and also accurate bearings of lighthouses, and the other, firing at night. There has never been anything brought forward which seems to me so likely to be successful as this apparatus. I think a large portion of it might be carried into effect. I will again thank Captain Croudace for his valuable communication.

ON IMPROVEMENTS IN APPARATUS FOR LOWERING AND RAISING, ENGAGING AND DISENGAGING SHIPS' BOATS.

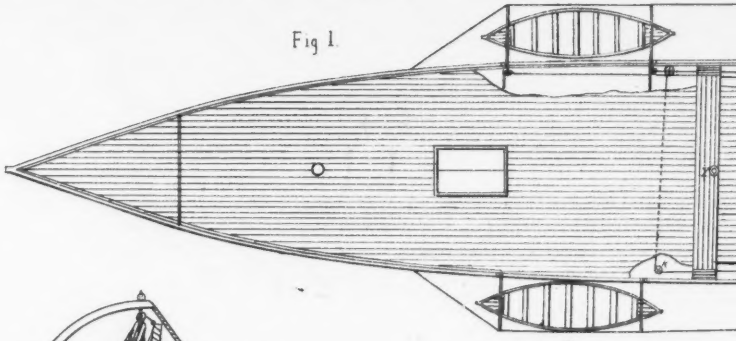
By A. FOLKARD, Esq., M. Inst. C.E.

THE accidents, resulting in loss of life, which have arisen out of the present methods of lowering and raising ships' boats at sea, induced me, in common with many others, to give careful attention to the subject; and, profiting largely by the criticism of the press upon the many ingenious inventions previously brought forward, I have endeavoured to meet all points of objection therein raised.

The measure of approval hitherto bestowed upon my efforts, induces me to hope that I may have successfully done so, as also that an explanation of the models now exhibited may not prove without interest to the members of this Institution.

FOLKARD'S PATENT BOAT

Fig 1.



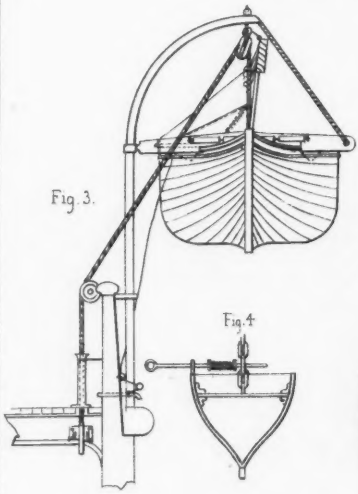


Fig. 3.

Fig 7.

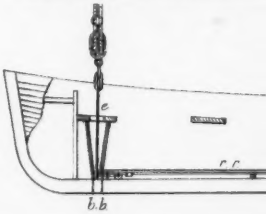


Fig 2.

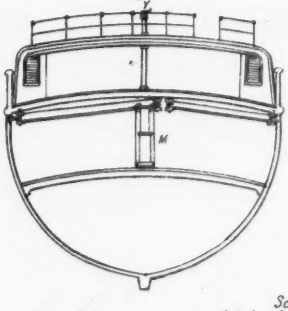
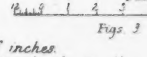


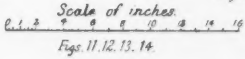
Fig. 4.

Fig. 9.



Figs. 3

Scale of inches.



Figs. 11. 12. 13. 14.

Fig. 5.

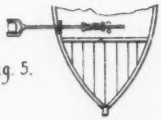


Fig. 11.

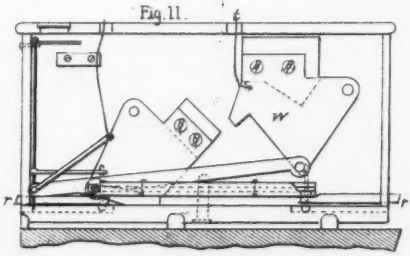
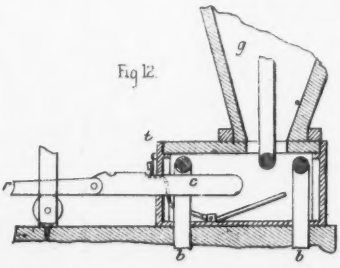


Fig 12.



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BOAT-LOWERING APPARATUS.

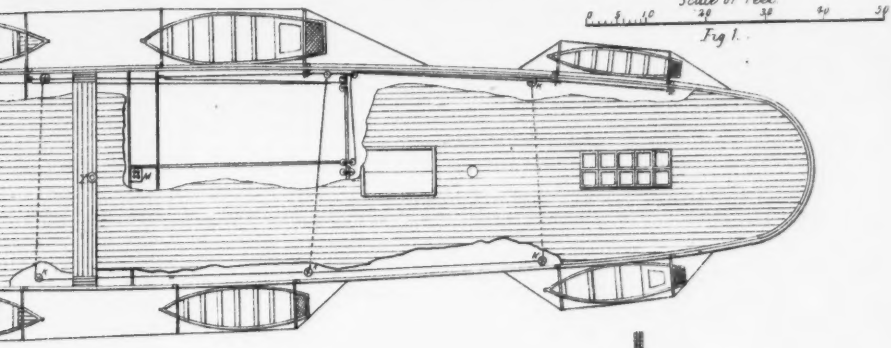
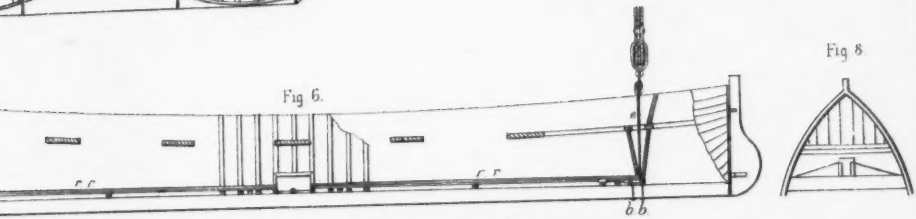


Fig 1.



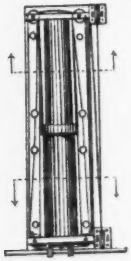
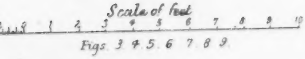
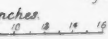


Fig. 9



Figs. 3 4 5 6 7 8 9.



14.

Fig 10

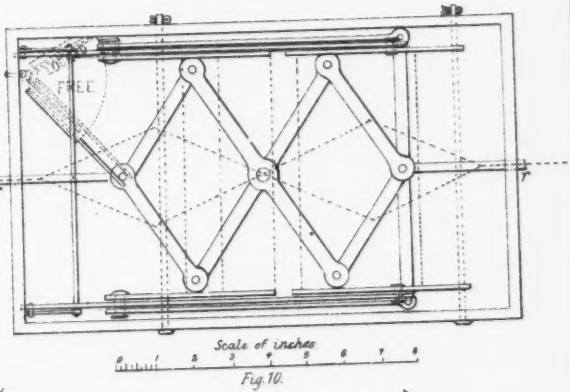


Fig. 10.

Fig 13.

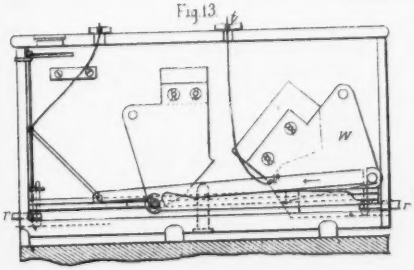
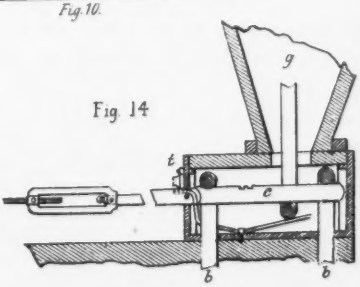


Fig. 14



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I divide the subject into two sections, taking—

Firstly, That portion of the design connected with the covering and securing the boats at the davits and their lowering and hoisting, and—

Secondly, The means I propose for connecting and disconnecting them to, and from, the falls by which they are so hoisted and lowered.

Section 1.—I propose to abandon the ordinary lashings, termed gripes, which require time and manual intervention to remove on an emergency, and in their place I substitute wrought-iron arms which, notched to receive them, sit firmly down over the gunwales, and being held in place by standing-rigging (see Plate xiv, Fig. 1), prevent all movement of the boat laterally or longitudinally, and admit of its falling free from them when lowered.

In the tropics it is necessary to shelter boats from the sun, and the present system of covers entails great delay in their removal.

The gripes above described aid me to simplify these. At the rear of each gripe I hinge two arms, which carry bars of wood or iron bent to the shape of the gunwale of the boat (Fig. 3). Upon these is stretched the main cover, and this can either be raised and trailed by a pull on the single rope leading to the deck, or can be raised by hand by the crew when entering the boat, which on lowering, leaves its cover suspended to the gripes. Small covers are provided for the bow and stern, which can be removed at any time after lowering.

The system of lowering I adopt, is as follows:—I suspend the boats either by single pendants or tackles, giving preference to the former (Fig. 3). They lead over wheels on the bulwark-rail, and pass through stand-pipes below the deck through a series of leaders, by which each pair of pendants are led to any convenient line fore and aft.

They are then united in a hook so as to form a single line, and thus ensure the working of both falls equally, and a consequent level keel both in hoisting and lowering.

In this large model, the hooks of all the pendants are engaged to any links in a main chain, which by a system of purchase is connected with the ram of a hydrostatic press (M, Figs. 1 and 2, and Fig. 9), the stroke of which is multiplied as desired by such purchase. In the model, it is so multiplied eight times.

Thus the weight of all the boats is transmitted to, and borne by, the water in the press.

To enable the boats to be worked individually, each pair of pendants pass through a brake (KKK, Fig. 1) by which they are firmly secured when the boat is hoisted. These brakes can be released either by the screw-wheels on deck, or by turning off the water in the hydraulic cylinder upon which the lower block is supported. This operation can be effected either individually or collectively from the bridge (Y, Figs. 1 and 2), but the scale of the model does not admit of my showing it here.

It is evident that the descent of the ram will only affect those boats of which the brakes are released; and thus, if I want to lower, say the launch, life-boat, and cutter, I have only to release the brakes of those boats, and, by opening the escape-cock of the press, they then descend

under perfect control, leaving the other boats still retained in position by their brakes.

The lowering can also be effected when desired (and certain occasions do render it desirable) by any man within the boat, who, by a line, controls the weighted lever of a second escape-cock situated near the particular boat, as in the smaller model.

I propose in some cases to adopt a smaller press for each boat. It will be bolted to the bulwarks, and by its multiplying purchase will wind up or pay out, the whole length of fall, whilst the several presses will have pipes to a connection below the bridge, by which they can be individually or collectively worked. This arrangement will obviate the necessity for brakes for separate control.

For hoisting, I have simply to force water into the cylinder of the press by a forcing pump, when the rise of the ram brings the boat well home into the gripes, where it is secured by its particular brake.

The ram can be rapidly let down for hoisting a second boat, or two or more can be hoisted together if the gear be made sufficiently powerful.

I claim for this first section of my design—

1st. That the ascent and descent are on a level keel.

2nd. That no time is lost in emergency.

3rd. That the descent is under such complete control that a child of five or six years old could lower or stop all the boats, even when filled with men.

4th. That if one man only in the ship retain his presence of mind, the boats can be lowered, even if the confusion be as great as prevented the operation with those unfortunate vessels the "Northfleet" and "Atlantic."

5th. That four or five men can, in hoisting, do the work now requiring twenty men.

6th. That the power is applicable to a great number of other useful purposes on board ship.

To lessen the danger of a boat being staved against a ship's side, I provide ashen or iron rods which fit into a ring in each pendant and have a roller to receive the blow against the ship's side, to meet which it is guided by hand (Figs. 4 and 5).

The force of the blow is largely met by a stout spring coiled round the rod, whilst the balance of force is expended upon the naturally elastic pendant.

Section 2 refers to the means of engagement and disengagement when the boat is in the water.

The principle on which I have designed this is, that the action with both falls must be coincident, so that neither fall can either engage or disengage without the other, and that both operations are automatic.

I have here an apparatus suitable for boats of any size.

Two eye-bolts are clenched through the keel at either end (*b b*, Figs.

6, 12, 14). Between them plays a stout bolt (*c c*, Figs. 12, 14). The bolts are connected to light iron rods (*r r r r*, Figs. 6, 10, 12, 13, 14) united in a small box by a system of levers technically termed a "lazy tongs," which give a differential but reversed motion to the rods and bolts (Fig. 10). The "lazy tongs" is actuated by two weights of different calibres (Fig. 10, 11, 13).

To the end of the falls I attach chains and shackles (*e e*, Figs. 6 and 7).

The gear is set at any time before coming alongside by a toggle (*t t*, Figs. 11, 13), which raises the major weight (*w w*, Figs. 11, 13), tending to throw the bolts through the eye-bolts (*b b*, Figs. 12, 14). But this is restrained by trigger-catches, or stops (*t t*, Figs. 12, 14), which fit into slots in the bolts.

On coming alongside, one man pushes the shackle down the guide (*g g*, Figs. 12, 14), lifting the trigger; but, as you observe, no motion takes place, and the shackle is still free, owing to the second trigger still restraining the drop of the weight; but on the other shackle being lowered, all hindrance to such drop is removed—the weight drops, and both bolts are thrust forward simultaneously. The boat is now engaged at both ends, and can be hoisted, nor can it afterwards be disengaged by wave action.

When lowering, the connection between the two weights is severed by a cord attached to the davits, and the smaller is now in a state of suspended motion, tending to withdraw the bolts, but this it cannot do whilst these last are strained upon by the weight of the boat. Should one fall slack without the other, you will observe no motion can take place because the other end is held, but when both falls slack simultaneously on the boat being completely waterborne, the weight drops and withdraws both bolts, setting the boat free.

This last operation has been accomplished by several very ingenious devices, but I am unaware of any instance in which the engagement has been similarly performed.

This is an operation attended with much hazard, and the extreme delicacy of all other proposals for releasing, has tended considerably to increase such hazard in the attachment.

It is difficult to avoid the omission of minor points within the limits of a paper like this, but I shall be glad verbally to explain any such which may have been so omitted.*

Commander BRENT, R.N.: May I ask what ship your apparatus was fitted in?

Mr. FOLKARD: In Her Majesty's Ship "Columbine," and in the "Hindostan," belonging to the Peninsular and Oriental Company.

Commander BRENT: If sand or anything else (for we have to do all sorts of work in harbour) should get into the box in the centre, would it stop its working?

Mr. FOLKARD: Not at all. The lazy tongs are made of brass, and they are all fitted closely together, so that it is impossible for any sand to get into the joints. A peculiar accident occurred when the apparatus was being tried in harbour. The crew on lowering, were to let go the falls suddenly, and one set of men let go one fall and let us drop into the water. No accident really resulted, because although one fall was slack it could not possibly disengage without the other, and this was acting afterwards with a boatful of water and sand.

* For full particulars, see *The Engineer* of March 27th, and *Iron* of April 4th, 1874.

Mr. BRODIE: Do you know by experiment whether a boat can be lowered by that apparatus in heavy weather?

Mr. FOLKARD: It has been done on the coast of Ceylon. One day when the "Columbine" was not able to go out, we took it out in another vessel and lowered the boat with it.

Admiral JONES: Does the hydraulic apparatus require much space? and at what distance from the sides of the vessel should it be?

Mr. FOLKARD: Only seven feet height between decks. The rule would be that the distance must indicate the amount of fall. In this instance I have taken it as 28 feet fall; that is about the maximum generally required. The hydraulic apparatus need not necessarily be in the centre, nor below deck. You would not have space for it in some cases. With reference to the other model now being prepared, there is a small press fastened under the bulwark for each boat, and the falls are wound up on a purchase there, so that nothing goes below the deck at all. Each cylinder has pipes leading to a central tube, which are worked by a lever, and by simply turning the lever to a certain point, you can produce any combination of boats. You can hoist one whilst you are lowering three others; or you can hoist two and lower two.

Commander BRENT: How quickly can you hoist? You have to watch your chance, and you want to start very quickly. Is the action of the hydraulic rapid?

Mr. FOLKARD: It entirely depends on the power you employ. I have provided for the case of a heavy sea, where in ordinary cases in the Navy the men run up the slack. I have an ordinary four-fold purchase that would be attached to the hook, and the slack would be run up in the ordinary way.

Commander BRENT: With a great number of men you do not want the hydraulic. It is more for ease in lowering, but it is useful in hoisting too?

Mr. FOLKARD: Yes, I think it is desirable that every means used for lowering should also be available for raising. And then again, in this system of hoisting, the full weight of the men is utilized, whereas in an ordinary ship I do not think more than one-third of the pull is utilised, taking them all through.

Mr. ARTHUR PRICE: Was the hydraulic on board the "Columbine?"

Mr. FOLKARD: No.

The CHAIRMAN: What is the expense of applying the hydraulic power?

Mr. FOLKARD: I am making an estimate for a P. and O. ship. I think the whole expense for fitting these freeing gear to each boat, and fitting a ship throughout, would be £300, fitted with separate presses.

The CHAIRMAN: Would the tubes take much space?

Mr. FOLKARD: No, they are very small tubes.

The CHAIRMAN: Do I understand that the boat could be detached by a man stationed here for the purpose, say two or three feet before it touches the water?

Mr. FOLKARD: No, the falls must slack.

The CHAIRMAN: In other systems the falls can and do become detached, sometimes to the injury of the boat.

Mr. FOLKARD: Undoubtedly it would be an advantage if it could be done.

The CHAIRMAN: Could it not be added to it?

Mr. FOLKARD: I think it might be added to it by simply allowing this joint to slip up.

Mr. STERLING LACON: I think Sir John Hay pointed out at the Institution of Naval Architects that having lowered one boat, you cannot immediately proceed to lower another.

Mr. FOLKARD: Precisely, and that is why I am having the other model made, carrying out Mr. Scott Russell's suggestion. Each boat will have a separate ram. Mr. Scott Russell asked me the time it would take to prepare the ram for the second descent, and I gave him the time, three-quarters of a minute, and I think Sir John Hay said "Under those conditions I withdraw my objection."

The CHAIRMAN: Still you get over it by having separate rams.

Mr. FOLKARD: Yes, by having separate rams.

A MEMBER: If you lower one boat and want to lower another one, how do you act? You see, if you lower one boat and then you want to lower a second, you cannot do so with the same apparatus without raising the ram.

Mr. FOLKARD: The ram has to be raised again to take the weight of the other boat. If I had a separate ram for each boat, each ram would work individually.

Commander BRENT: I consider the method of covering and securing the boats at the davits a most valuable part of the invention. I have recently had occasion to see the boats of large merchant ships so stowed on board, and with their covers, &c., so coated with repeated layers of paint and varnish, that it would be a long affair to prepare them for lowering in an emergency. The fact, too, that here the old system of "hooking on" is done away with, and that the engagement is automatically performed, is a very important gain.

Captain CROUDACE: The method of lowering now exhibited is very novel, and appears to me likely to be of great service. The facility with which the boats can be lowered on an emergency, is very apparent from the model.

The CHAIRMAN: We have had a very interesting paper on the important subject of lowering and hoisting boats at sea, which has always been one of great anxiety to those in command of ships; and it certainly seems to me that Mr. Folkard has succeeded in obviating a great part of the difficulty. Could you tell us whether there was a report of the man-of-war's boat on which it was tried? Was it satisfactory?

Mr. FOLKARD: I have not the printed paper, but it was very satisfactory. Captain Baird of the "Juno," who attended the trials, wrote to me to say it was most satisfactory, and he hoped it would be universally adopted.

The CHAIRMAN: I am sure you will all agree in returning your thanks to Mr. Folkard.

"BRITISH INTERFERENCE WITH REVOLTED SPANISH SHIPS" IN 1873.

By Captain HUGH MCNEIL DYER, R.N.

ALTHOUGH general interest in the stirring events which took place on the south-east coast of Spain, in the latter part of 1873, has most likely passed away, yet there is much matter contained in the correspondence recently published for the information of Parliament, which deserves the serious consideration of statesmen, and, above all, of naval Officers. It would be well also for the country at large to read this series of letters, to learn how easily the indiscretion of an Officer in command of a ship or squadron on foreign service, may lead to serious international difficulties, and how highly important it is that those Officers should have the best possible information on international law, and should be provided with the best possible authorities to refer to. These points have not been sufficiently attended to heretofore, but we hope more attention is being given to them by the Admiralty now.

Having been on the coast of Spain during the period I allude to, and having studied the correspondence, I am of opinion that a plain and authoritative definition should be at once laid down in the Admiralty Instructions to naval Officers, of the term "pirate."

It should be laid down under what circumstances a ship is entitled to be recognised by a neutral as having belligerent rights and powers.

There should be instructions, applicable to all cases, of the extent of interference allowable to our Officers, for the protection of British life and property when endangered by the action of belligerents.

It may be remembered that in July last year there was a revolt against the Central Government of Spain by the "intransigente" party in that country. Several important towns declared for the Intransigentes, among them Carthagena, and the crews of the ships of war at that port joined the movement, whereupon the Central Government at Madrid published a decree declaring the crews of these ships to be pirates, and authorising foreign Powers and their naval forces to capture them, even in Spanish waters, and to bring them to trial.

The second article of the decree stands thus:—"The Commanders "of the vessels of war of the Powers friendly to Spain are authorised "to detain the vessels mentioned in Article I (those in the hands of "the Intransigentes at Carthagena), and to try their crews as pirates, "the Spanish Government reserving to itself the property of the "vessels, claim to which will be duly made through the diplomatic "channel."

In consequence of this decree, instructions were transmitted from our Government to their Officers, that if the revolted ships committed any "acts of piracy" affecting British subjects or British interests, they were to be treated as pirates, "the decree of the Spanish Government having deprived them of the protection of their flag." It will be well to consider who were the Spanish Government.

From the time of King Amadeo's abdication, no form of Government in Spain has been recognised by England, and it was forbidden our ships to salute their adopted national flag, although our Minister has been in unofficial or "officious" communication with the *de facto* Government at Madrid. In April, 1873, a general election took place of members to the Constituent Cortes, which was to provide a form of government for the country. Of 358 members elected to Cortes, all, except about a dozen, promised their constituents to support a "Federal Democratic Republic," after the pattern of the United States of America; but when they got to Madrid, those in power managed to put off from time to time the decree which was to define the limits of the Federal provinces, which were to have separate State Governments, and before a month, a majority of members were evidently in favour of a unified Republic, after the pattern of France, although they were afraid to state their change of views openly. Then the "intransigente," or "irreconcilable" members, that is, irreconcilable to any form of central government, threatened that, if some immediate steps were not taken to fulfil the wishes of the people declared at the elections, and define the Federal States, &c., they would go down to the country, and raise the people in arms to enforce their demands. Finally, 60 members did so. They formed a new Government, whose temporary seat was at Carthagena, appointed Roque Barcia President, and Juan Contreras Captain-General.

Unfortunately for the "intransigentes," the "internationalist" traderiots at Alcoy, San Lucar, and elsewhere, which arose at this time, were attributed to them, so that foreigners looked upon "intransigentes" as Communists. They occasionally also hoisted the red flag on their forts and ships, and undoubtedly they were extreme in their Republicanism; still they had more right on their side than they have, as a

rule, been given credit for; and from personal knowledge I can say that they did not deserve all the bad names they were called; and I believe they deserved respect from neutrals as a powerful party in Spain.

But the Intransigentes injured themselves most of all, by sending their ships to the seaport towns, to exact contributions for the furtherance of their cause. Of course the people who were forced to contribute, ceased to be Intransigentes then and there, and did not fail to cry out against the "brigands" that robbed them; and foreigners did not like these proceedings, which looked too much like the plundering of robbers. The commanders of two French men-of-war spoke of it to me as "brigandage." The captain of an American corvette told me he would capture the revolted ships if he found them at sea. The German Commodore denounced the requisitioning to be piracy, and as for our own Officers, I find Sir Hastings Yelverton says, with reference to the proceedings of Contreras, at Almeria, "This was clearly an act of piracy coming within the scope of their Lordships' telegram of July 24th."

The first action taken in this matter was by the German Commodore Werner, who seized a small steamer, the "Vigilante," as a pirate when entering the port of Carthagena from a requisitioning cruise, because she was flying a red flag "which was unknown amongst military navies," as he says in his notice to the Junta. He did not treat her crew as pirates, however, but landed them at Carthagena, together with the 6,000 dollars they had requisitioned, and he sent the vessel to Gibraltar under the German flag, where she was, without trial, handed over, by the authority of our Governor, to the representatives of the Madrid, or Centralist party. This is a matter deserving much attention.

In the despatch from the Foreign Office to the Admiralty, dated 24th July, it is laid down that, if the Intransigente vessels did no act of piracy affecting British interests, they were not to be interfered with; it is therefore difficult to see on what grounds the "Vigilante" was given over to the Centralistas. Was she a pirate? Then she should have been treated as one, and put into the Admiralty Court for legal disposal. Was she a vessel with belligerent rights? Then she should have been allowed to exercise such rights. At any rate, as she had in no way interfered with British subjects or British interests; once within British jurisdiction, she should have been treated in accordance with the rule laid down by our Foreign Minister.

Then came the affair of the "Vittoria" and "Almansa." These ships put to sea with troops on board to assist their party at Malaga, Cadiz, and elsewhere. As they passed along the coast they endeavoured to levy contributions to aid their cause. Being refused at Almeria, they fired on the town and injured much property, some of which belonged to British and German subjects. They then procured 10,000 dollars at Motril, and were prepared to land at Malaga, when they were prevented by Commodore Werner, of the German ironclad "Friedrich Carl," and Captain the Honorable W. J. Ward, of Her Majesty's ship "Swiftsure," who agreed to "forcibly oblige the Spanish ships to return to Carthagena." This was done; and Commodore Werner also took

General Contreras the Commander of the expedition out of the "Almansa" on board the "Friedrich Carl," holding him prisoner until the will of his Government was known, as the person responsible for the piratical action of these ships. Afterwards, it was decided to oblige the crews of the "Vittoria" and "Almansa" to land at Carthagena, and to retain the ships until instructions were received. Captain Ward certainly understood that these ships had committed a "piratical act affecting British subjects and interests," and Sir Hastings Yelverton states that it was "clearly so," yet they were not treated as pirates.

But I find Sir Hastings also says, "Had he (Contreras) been an "authorised representative of a party in opposition to the existing "Government, it would have been clearly the duty of the German ship "and 'Swiftsure' not to have interfered." Surely Contreras, the Captain-General of the forces, naval and military, in favour of the Intransigente cause, was an authorized representative of that party!

Captain Ward had interfered because he considered the bombardment of Almeria a piratical act affecting British subjects, &c., but, if so, why was not the concluding part of the instruction carried out, and the ships "treated as pirates?"

There is a curious precedent in naval history for Captain Ward's action. On the 2nd February, 1812, Captain Sir James Lucas Yeo, in the frigate "Southampton," met a frigate, the "Amethyste," under strange colours at sea off Hayti, and commanded by a man named Gaspard, who held a commission from one "Borgelat," calling himself "General-in-Chief of the South of Hayti." Sir James had been ordered to respect the flags of Christophe and Petion, then contending for the government of Hayti; but not knowing anything of "Borgelat," he directed Captain Gaspard to accompany him with the "Amethyste" to Port Royal. Gaspard refused. An action was fought. The "Amethyste" had 105 men killed, 120 wounded, and was dismasted. She then surrendered. The remainder of the crew were landed; the "Amethyste" was taken to Port Royal, and was afterwards handed over to Christophe. The cases are very similar, except, fortunately, there was no action with the "Vittoria" and "Almansa," and no killed and wounded.

But I don't think, when Captain Ward forced these ships to return to Carthagena, he contemplated the course of action our Government was about to follow. His object was to save Malaga from bombardment, and to obtain time to receive more precise instructions from home. The forcing them back to Carthagena was one thing; the removing them to Gibraltar for the purpose of handing them over to another political party was another, and it is hard to see how the latter course of proceeding can be justified.

This decision of our Government nearly led to much bloodshed. It was merely the fact of our Admiral being a firm, judicious, able man, that prevented it.

The Intransigentes had made up their minds to leave the ships in our hands until the issue between them and the "Centralistas" was decided; and this latter party had shown so much weakness, so little

desire to meet their enemy, so little of even ordinary manliness, that it only required a bold leader to put the Intransigentes into power.

There was a party among the Intransigentes at Carthagena who did not approve of the proceedings of Contreras in attacking Almeria, and the crews of the ships forming the Intransigente squadron doubted their Captain-General also, so that although they protested strongly against the indignity put upon them, yet they submitted quietly to the order from Commodore Werner and Captain Ward to leave their ships. This order is as follows:—

"Commodore Werner commanding His Imperial Majesty's ship "'Friedrich Carl,' and Captain Ward, commanding Her Britannic "Majesty's ship 'Swiftsure,' declare in respect of the crews of the "armed Spanish ships 'Vittoria' and 'Almansa,' that these said crews "may remain on board their ships until to-morrow at 6 P.M. If they "don't leave their ships at that time of their own free will, and with-"out arms, the two named Captains will cause them to leave. The "Officers to retain their swords.—Given on board the 'Friedrich Carl' "at Escombrera, August 3, 1873."

But when the Intransigentes heard that the "Vittoria" and "Almansa" were to be taken from under the guns of the hill forts of Carthagena, and in the face of their three remaining ironclads, for the purpose of handing the detained ships over to the Madrid party, whose forces never could and never would have taken them from where they were, had we simply abandoned the two vessels, as the Germans had done, then it was not to be wondered that the Intransigente leaders swore they would die sooner than suffer such an indignity, and had they been brave men they would have done so. But our previous proceeding in forcibly landing the crews appears to have completely cowed them, and, notwithstanding all their protestations, not a shot was fired or a movement made as the detained ships, with British colours flying, went to sea. The firm attitude taken by our Admiral saved us from a collision into which the instructions from our Government so nearly led us. For how did these ships differ from others in possession of the Intransigentes? In the subsequent instructions sent to our Officers, the first which are clear and unmistakable in their sense, dated 24th September, 1873, it is laid down: "Her "Majesty's Government would desire that it should be specially im-"pressed on naval Officers that it is no part of their duty to interfere "to stop general naval operations undertaken by insurgent ships "against Spanish seaports!"

It also says: "If an attack is made at sea upon any foreign vessel "by a ship belonging to no recognised Government who can be made "responsible for such act, such attack is piracy; but that as regards "an attack by a ship in possession of insurgents against their own "domestic Government, upon the ships of that Government at sea, or "upon its cities, ports, or people, within the territorial limits of their "own nation, such attack is not piracy."

So it is evident that the British Government did not think General Contreras had committed a piratical act in the "Vittoria" and

"Almansa," although our Officers believed he had, and interfered with his proceedings on that ground.

In Earl Granville's despatch to Lord Lyons, dated 20th August, he says:—"It is true that, owing to distance and difficulty of communi-"cation, these instructions did not reach the British Officers in time "to influence their conduct, and therefore, much as Her Majesty's "Government regret that those Officers should have taken any pro-"ceedings inconsistent with the policy on which those instructions "were founded, they are not prepared to impute blame to those Officers "who, in circumstances of no ordinary difficulty, were only able to act "according to the best of their judgment."

The summary of this matter is: The "Vittoria" and "Almansa" were forcibly directed to return to Carthagena, because they had committed a "piratical act affecting British interests." The crews were forcibly ejected from these ships. Then it was decided that they had not committed a piratical act. Yet they were not returned to the same party in the civil struggle in Spain from which they were taken, but were given to its enemies, although Lord Granville said in his despatch dated August 20th, 1873, speaking of the policy of the British Government, "They desire and intend not to interfere in any way with the affairs of Spain."

It is probable that Lord Granville thought, as we all did when Spanish troubles first began, that the "Intransigentes" were scoundrels undeserving any consideration—communists and anarchists. Some of us present in Spain changed our opinions, although we could not sympathise with their politics, yet they were about as honest as any other party. In their raids on the neighbouring towns to provision Carthagena, they "requisitioned" in the most orderly manner. One of their Officers told me that it was a warlike act they had learnt from the Franco-German war, and it was carried out according to precedent. No private plundering or requisitioning was allowed. An inventory was taken of all goods removed from the public buildings, and receipts were given to private individuals for their contributions, to be paid for at the end of the war.

A very pertinent question was put to me by the Commander of the French war steamer "Daim." If the Centralistas had done a similar act to that of the Intransigentes; that is, had they sent their ships boldly into Carthagena as they might have done, and as Commodore Werner said he would have had no hesitation in doing, and bombarded the town, without giving previous notice to foreigners, should we have seized those ships and handed them over to the Intransigentes? I am sure we should not.

It is therefore plain that these Intransigente ships were allowed only imperfect and limited belligerent rights.

Another circumstance worthy of attention, is the declaration by Commodore Werner and Captain Ward that the waters of Escombrera must be neutral to both Spanish parties, and Admiral Yelverton confirmed this until the "Vittoria" and "Almansa" sailed, and both Intransigentes and Centralistas submitted to it, though Admiral Lobo

complained to Sir H. Yelverton that proclaiming this anchorage to be neutral was a violation of the Law of Nations.

The force at the disposal of Commodore Werner and Captain Ward being comparatively small, and the Madrid party having sent some small ships to demand from the German and British charge, the detained ships "Vittoria" and "Almansa" then laying with their foreign guards in the waters of Escombrera, about $1\frac{1}{2}$ miles outside the port of Carthagena, and directly under the guns of Fort St. Julian, the foreign Commanders felt obliged to declare Escombrera Bay to be neutral waters, so as to keep both Spanish parties out of it, and so to prevent further complications arising. Captain Ward, in a despatch to Sir Hastings Yelverton, dated August 12th, 1872, says:—

"Commodore Werner and myself informed the Junta that we should "enforce the neutrality of the waters of Escombrera in consideration "of our situation with respect to the captive Spanish vessels."

Again Admiral Yelverton says in a despatch to the Admiralty, dated 25th August:—"These vessels ('Vittoria' and 'Almansa') now "lie in the neutral waters of Escombrera, absolutely under the guns "in occupation of the insurgents, and surrounded by Italian, American, "German, and English ships-of-war."

On September 6th, Sir Hastings writes to the Admiralty,—"Yesterday I received a notice, through the British Consul, in which "the Junta of Carthagena declare the waters of Escombrera Bay to "be no longer neutral." And the "Vittoria" and "Almansa" having been removed on the 1st of September, our Admiral agrees that the neutrality was at an end.

Our Government never seem to have remarked upon this arbitrary and unprecedented act of our Officers declaring the waters commanded by the guns of a Spanish fortress to be "neutral;" but, it must be remembered, it was done in the first instance by Captain Ward as an act of self-preservation, his force being too small to allow any advantage to the Intransigentes who repeatedly threatened him with an attack, and made signs of commencing one; afterwards the neutrality was continued with the tacit consent of both Spanish parties, as a matter of convenience to them and to foreigners.

Then there was our demand for four days' grace for Alicante, before the Intransigente ships were allowed to open fire upon it, supplemented by the French demand for two additional days, making six in all; a very wise and merciful demand, but is it to be a precedent for our interference with belligerents for the future?

These ships, and every ship of war that goes to sea, ought to have full and equal rights with all belligerents, or none at all. If we do not mind, we shall have limited liability companies sending ships to sea to enforce some good trading monopoly. As yet, there is no written international law accepted as absolute authority. It is time it should be begun, and its first definition should be "A pirate!"

A naval Commander has police duties to perform, not legislative. If he finds ships doing questionable acts under doubtful authority, he stops them, if strong enough, and deserves no blame if he has made a mistake, but the clearer the law is made, the less liable will he be to make mistakes.

A FEW NOTES ON CAPTAIN DYER'S PAPER.

By Vice-Admiral Sir FREDERICK W. E. NICOLSON, Bart., C.B.

CAPTAIN DYER'S paper, giving a clear and concise sketch of the transactions on the south-east coast of Spain in the summer of 1873, would probably have received some additions, had he not been too much occupied by the duties of an appointment he has recently accepted.

These transactions were so peculiar, and the questions raised by them so interesting to Naval Officers, that I have ventured to add a few notes, chiefly consisting of extracts from well known works on the Law of Nations. Both Captain Dyer's paper and my notes have been read by the Naval Officer best qualified to point out any errors of fact; it is therefore hoped that, brief as they are, they contain a faithful account of what occurred at Carthagena, and in its neighbourhood, and a fair commentary on those occurrences, and on the instructions issued to the Naval Officers engaged in the transactions described by Captain Dyer.

Every Naval Officer of any standing must have felt on many occasions during his active career the want of some guiding authority on questions of International law; it is therefore not suprising that Captain Dyer, who witnessed most of the transactions near Carthagena, should ask that the term "pirate" be authoritatively defined, and that "it should be laid down under what circumstances a ship is entitled to "be recognised by a neutral as having belligerent rights and powers;" and that "there should be instructions applicable to all cases of the "extent of interference allowable to our Officers for the protection of "British life and property when endangered by the action of belli-"gerents."

But, however natural it may be for the Naval Officer to ask for clear definitions, and "instructions applicable to all cases," we shall find, on a closer examination of the points on which Captain Dyer seeks for guidance, that there is some difficulty even in defining the term pirate; and as to the latter points, it is impossible to lay down rules applicable to all the varying circumstances under which naval Officers may be required to protect British life and property.

Commencing with the term "pirate," let us see how that term is defined in some of the text books on International law. Professed pirates who attack and plunder any vessel are now-a-days very rare, though instances have not been wanting in recent years of piratical boats from the coast of Morocco attacking merchant vessels of any nation; and in China, piratical junks are still to be found.

Quoting Sir Leoline Jenkins, the well known Judge of the Admiralty Court about the end of the seventeenth century, Mr. Prendergast writes:—*

* Law relating to Naval Officers. Prendergast, Part I, p. 30.

"All pirates and sea rovers are, in the eye of the law, *hostes humani* "*generis*, enemies not of one nation, but of all mankind, outlawed by "the laws of all nations. Everybody is commissioned, and is to be "armed against them to subdue and root them out."

Lord Stowell, perhaps the highest authority of all the judges who ever presided over the Admiralty Court, says, "With professed pirates "there is no state of peace. They are the enemies of every country "and at all times, and therefore are universally subject to the extreme "rights of war."

"Piracy is robbery, or a forcible depredation on the high seas "without lawful authority, and done *animo furendi*, and in the spirit "and intention of universal hostility."*

Such are some of the definitions of a professed pirate.

The case of the insurgent Spanish vessels is of a different character, which even the decree of the Madrid Government, quoted by Captain Dyer, could not alter so far as to make the crews of the vessels pirates by the law of nations, and justiciable in the courts of any foreign nation; though no doubt such was the intention of the Spanish Government; for they authorise the vessels of war of friendly powers to detain the insurgent vessels, try their crews as pirates, and return the vessels to the Madrid Government on being claimed through the Spanish diplomatic agents!

Such a decree is clearly *ultra vires* so far as foreigners are concerned, though the Spanish Government is entitled to declare the offence of the insurgent crews to be "piracy," and justiciable as such before the Spanish tribunals. A few quotations will make this clear.

"The municipal laws of a State cannot constitute an offence to be "piracy which is not so characterised by the Law of Nations."†

Quoting Bello, the South American publicist, the editor writes:—‡

"No sovereign has the right of qualifying as piracy those acts that "are not comprehended in the definition of this crime as generally ad- "mitted. A Government can declare that this or that offence, perpe- "trated on board of its own vessels is a piratical act. The American "Congress declared in the year 1790 that every crime committed at "sea, which, if committed on land, would be punishable by death, "was piracy. Nevertheless, as this law goes beyond the definition of "the crime by the Law of Nations, it would not render legal the juris- "diction of the American tribunals over acts committed under the flag "of another nation which were not strictly piratical."§

"Pirates being the common enemies of all mankind, they may be "lawfully captured on the high seas by the armed vessels of any state, "and brought within its territorial jurisdiction, for trial in its "tribunals. This proposition must be confined to piracy as defined by "the Law of Nations, and cannot be extended to offences which are "made piracy by municipal legislation."

* "Kent's Commentaries," Part I, section ix.

† Phillimore, vol. i, p. 381.

‡ Wheaton, edited by Lawrence, p. 247; note, 2nd edition.

§ *Ibid.*, p. 255.

‖ Montague Bernard; Neutrality of Great Britain, 1870, p. 768.

"A person making war in any customary way under the flag of a "*de facto* Government against a Government which has a claim on his "allegiance, is unquestionably a rebel; but it is a mistake to suppose "that he can be brought under the condemnation of International law "by calling him a pirate."*

"A rebel is not dangerous to anybody except the Government "against which he is fighting and its adherents, unless he makes of "the belligerent character which he assumes a cloak for indiscriminate "plunder; and in the chance that he may do this, if there be no one "to keep him in order, lies the only conceivable plea—and that an in-"sufficient one—for his being hunted down as a pirate."

"You will find no very precise definition of the offence of piracy; "it is sometimes defined as robbery or murder on the high seas, or "depredating at sea without a commission; other definitions are, per-"haps too broad and too narrow for absolute precision, too narrow "because there are some cases or some acts which are piratical, "although they do not strictly preclude the persons committing them "from all protection; and too broad, because the definition robbery "and murder on the high seas would include an offence committed by "one man against another on board a vessel remaining under the juris-"diction of the country whose flag she carries. Such offences would, "by the Law of Nations, be subject to the exclusive jurisdiction of "the nation on board whose vessels they are committed.

"The truth is, that for Naval Officers it is not necessary to struggle "for a very precise definition; the cases in which they are called upon "to interfere are not very frequent, and are seldom otherwise than "clear; that is, Officers are not called upon to act unless in cases "where a vessel is plainly under the control or in the possession of per-"sons, and by whom she has been unlawfully seized, and afterwards "used for unlawful purposes."

"It is not usually the duty of an Officer to arrest, as pirates, foreigners "who are engaged in carrying on wars against their own Governments, "although it may be that the war has not been recognised by the "Government of Great Britain.

"In such case, whatever those persons may be engaged in doing, it "clearly differs from the offence of piracy, and does not create that "general danger to persons navigating the seas which would justify "foreign nations in treating them as subject to foreign jurisdiction.

"A recent example is that of the two Spanish ships seized near "Carthagena and found to be manned with insurgents. Clearly no "one would have contended that it would have been right to bring the "persons on board those ships to England and try them as pirates in "the Central Criminal Court. They were not pirates in that sense of "the term, or indeed in any substantial sense of the term, and the con-"sequence was, that when we had got them we did not know what to "do with them."

"An act which is not piracy by the Law of Nations cannot be made "such by the fact that the name and penalties of piracy have been "affixed to it by the municipal law of any State.

* Montague Bernard; Neutrality of Great Britain, 1870, p. 119.

"For example, if the law of England declares the slave trade to be "piracy, the effect of that would be that slave-trading would be "punishable as piracy in English Courts, but only when the offence "was committed either by British subjects or by persons on board of "a British ship, and therefore locally subject to jurisdiction."*

Although Mr. M. Bernard makes no allusion to the decree of the Madrid Government authorising foreign vessels-of-war to treat the revolted Spanish crews as pirates, he is manifestly of opinion that no municipal law, and far less a mere decree, can constitute even the most reprehensible act to be piracy under the Law of Nations.

We may now examine the Instructions furnished to our Naval Officers on the south-east coast of Spain.

A brief letter from the Foreign Office to the Admiralty on July 24, 1873, quoted by Captain Dyer, contains the following directions which were conveyed to Sir Hastings Yelverton, by telegram, from the Admiralty:—

"If the insurgent vessels commit any acts of piracy affecting British "subjects or British interests, they are to be treated as pirates, the "decree of the Spanish Government having deprived them of the pro-"tection of their flag, but if they do no such acts they are not to be "interfered with."

The phrase "Acts of Piracy affecting British interests," is very vague; an act of piracy against persons and property at sea, or, in other words, against a vessel, presents a clear and intelligible definition; but the term "British interests" may easily be construed to include persons and property on shore; and this appears to have been the view taken by Sir Hastings Yelverton when he declared that the operations of General Contreras at Almeria were "clearly an act of "piracy coming within scope of their Lordships' telegram of July 24th."

This telegram does not appear to have reached Captain Ward previous to the seizure of the two insurgent vessels by himself and Commodore Werner.

Whatever may have been the views of the Government when the instruction of July 24th was issued, the letter from the Foreign Office to the Admiralty of September 24th, 1873, by which our naval Officers are to be subsequently guided, gives a more defined and, in some respects, a different view of what is, and what is not piracy, and it points out very clearly how far the interference of our Naval Officers is to go.

Previous to the bombardment of a town, the insurgent vessels are to be required to allow sufficient time for British life and property to be placed in safety, and then the letter proceeds to state:—"Her Majesty's "Government would desire that it should be specially impressed on "Her Majesty's Naval Officers on the coasts of Spain that it is no part "of their duty to interfere to stop generally naval operations under-"taken by insurgent ships against Spanish seaports." . . . .

"Her Majesty's Government, also, would desire that British naval

* Lectures at the Royal Naval College, by the Right Honourable M. Bernard, February 18, 1874. The extracts from these lectures are made from the shorthand writer's notes, which have not yet been revised by Mr. Bernard.

"Officers should be reminded of the Instruction of July 24th, which "limited interference with insurgent ships to those which should "commit any acts of piracy affecting British subjects or British inte- "rests, and that it should be pointed out to them that if an attack is "made at sea upon any foreign vessel by a ship belonging to no recog- "nised national Government, who can be made responsible for such "act, such attack is piracy; but that as regards an attack by a ship in "possession of insurgents against their own domestic Government, upon "the ships of that Government at sea, or upon its cities, ports, or "people, within the territorial limits of their own nation, such attack "is not piracy; and that for this purpose it makes no difference what- "ever that foreigners resident within that territory, or their property, "may be exposed to danger from such operation."*

This quotation has been repeated, although it has already appeared in Captain Dyer's paper, as he has omitted, probably as unnecessary to illustrate the point he was then considering, the last sentence, which is of great importance, as showing that the fact of foreigners and their property being endangered does not constitute the attack of an insurgent vessel, under the circumstances above stated, to be an act of piracy; whereas, as already observed, the Instructions of July 24 may be easily construed to convey a different meaning.

The difference between the Instructions of July and September may possibly have arisen from the former having been issued previous, and the latter subsequent, to consultation with the law officers of the Crown. At any rate, the doctrines laid down in the later instruction are more in accordance, than the former, with the generally accepted maxims of International Law on the subject of piracy.

Passing from the questions of what is a pirate or what is piracy, we come to Captain Dyer's second and third suggestions that "it should "be laid down under what circumstances a ship is entitled to be recog- "nised by a neutral as having belligerent rights and powers," and "that instructions should be issued, applicable to all cases, of the "extent of interference allowable to our Officers for the protection of "British life and property when endangered by the action of belli- "gerents."

There are no questions of International Law more complex or more difficult than those arising from the relative positions of neutrals and belligerents, and the cases where our Officers are called upon to protect British life and property are so various, and depend so entirely on the peculiar circumstances of each case, that it would be impossible to lay down beforehand "instructions applicable to all cases."

No better proof could be given of this impossibility than is furnished by the occurrences on the coast of Spain described in Captain Dyer's paper. Could any instructions, however carefully prepared, have anticipated the anomalous state of affairs on that coast in the summer of 1873, so as to furnish beforehand a trustworthy guide to our Officers, who were doubtless placed in a most embarrassing position in respect to the Carthagena insurgents and their vessels?

* Parliamentary Papers, pp. 58, 59.

It may be useful, however, to make a few remarks on Captain Dyer's suggestions.

The first question that presents itself is one of considerable difficulty, which must be left to the decision of the neutral Government, namely, what are the circumstances entitling a community in revolt to be considered as a belligerent? and when it has been decided to acknowledge this state of belligerency, the time for promulgating such decision becomes an element of great importance.

For instance, one of the complaints urged against the British Government by that of the United States, was the "precipitate and "unprecedented" recognition of the Confederate States as belligerents—a recognition to be clearly distinguished from the recognition of a revolted community as a separate and independent State. Notwithstanding all that has been stated by the Government of the United States, it is manifest that the accordance of belligerent rights to the Confederate States on the part of neutral nations was inevitable, especially after the proclamation by the President of the United States of a blockade to be established on the coast in the possession of the Confederates.

Lord Russell thus describes the position of affairs in North America in the spring of 1861:—

"Seven combined States had declared in favour of the insurrec-
"tion; three more States, including the great and powerful State of
"Virginia, were preparing to join them. These States commanded
"upwards of 3,000 miles of sea coast, and comprised more than
"5,000,000 people, exclusive of negro slaves. The President of the
"insurgent Government had proclaimed his intention of issuing
"letters of marque and reprisal, while the President of the United
"States had proclaimed his intention to establish a blockade of all
"the ports of the Southern States; and the Commander of Her
"Majesty's Naval Forces on the North American station earnestly
"solicited instructions for his guidance. In view of these extra-
"ordinary events, unexpected and undesired, Her Majesty decided
"to proclaim her neutrality in this contest; to allow the belligerent
"blockade of more than 3,000 miles of coast, including, of course,
"the right of search, detention, and capture, on the part of the United
"States; and on the other hand, as in duty bound, to recognise in the
"so-called Confederate States the right of a belligerent Power."*

The Insurgents at Carthagena were in a very different position; their power on shore was limited to a small area, and the weakness of the Spanish Government at sea alone enabled the Insurgent vessels to leave the harbour.

This freedom of the Insurgent vessels to issue forth on their predatory expeditions against the Spanish seaport towns placed our Officers in a position of great perplexity, especially as they were for some time without special instructions, and many of the towns on the seaboard contained incredible quantities of British property.

There is nothing in the papers published to show that the British

* Alabama Papers, p. 126.

Government ever intended allowing belligerent rights to the Insurgents; nor are there any indications of a strict neutrality in the acts of the British Government, except allowing the town of Alicante to be bombarded after the six days' delay demanded by the English and French Admirals, to allow English and French subjects time to remove their goods.

While the two ships taken from the Insurgents are delivered up to the Spanish Government before the struggle is over, other Insurgent vessels are to be prevented by force from bombarding any town until sufficient time has been allowed for placing British life and property in safety. This is, no doubt, a very humane provision, and evidently beneficial to British interests, yet it is hardly the act of a strictly impartial neutral, for the delay in the attack thus forced upon the Insurgents might possibly have been of the greatest advantage to the Government party, by giving time either for reinforcing the garrison of the threatened town, or otherwise adding to its means of defence.

An instance of rigid neutrality exercised under circumstances which must have been most painful to the British Officer in command, occurred at Valparaiso in 1866. Chile and Spain being at war, a Spanish squadron appeared off Valparaiso, and after a short interval, of which the merchants do not appear to have availed themselves, for removing their goods, the Spanish Commander bombarded the town and destroyed a considerable quantity of neutral property. The merchants at Valparaiso vehemently denounced both the British Admiral and the British Minister for not forcibly preventing this bombardment. These Officers, however, considered that a strict neutrality was imposed upon them by their instructions, and in this view they were upheld by the British Government.*

The Spanish Commander, acting under imperative orders from his Government, was compelled, apparently with reluctance, to bombard a defenceless city, and this act, though falling within the strictly legitimate rights of a belligerent, was all the more reprehensible, as the British and French Governments were at the very time endeavouring, with the full concurrence of the Spanish Government, to bring about a reconciliation of existing differences between Spain and Chile, and were kept in total ignorance of the orders sent by the Spanish Government to their Commander in the Pacific.†

One other instruction from the Government to our Officers on the Coast of Spain remains to be noticed. It is contained in a letter from the Foreign Office to the Admiralty, directing instructions to be sent to the Naval Commander on the coast of Spain not to sanction or permit the participation of any British Officers in the surrender of any prisoners captured on board the revolted vessels to the Spanish Government, or in landing such prisoners at a port in the hands of the Spanish Government, giving due notice to the latter. This was a wise and humane provision, for it would indeed have been monstrous had

* Lord Clarendon to Mr. Thompson, British Minister in Chile, May 16, 1866.

† Parliamentary Blue Book; Lord Clarendon to Sir J. Crampton, British Minister at Madrid, May 16, 1866.

these prisoners been delivered up, as it may be presumed that the leaders at least would in all probability have been executed.*

Having thus briefly endeavoured to show that the questions asked by Captain Dyer cannot be very easily answered, and that instructions applicable to all cases where neutrals and belligerents come in contact, cannot possibly be laid down beforehand, it may be asked, are Naval Officers to be left entirely without guidance? Far from it. There are text books on the Law of Nations not difficult to be procured, which will indicate the leading principles of international law, and recently a valuable series of lectures has been given at the Royal Naval College at Greenwich, by the Right Honourable Montague Bernard on the points of international law most likely to concern naval Officers; and it is to be hoped that these lectures may soon be published in a convenient form, so as to form a ready text book of international law.

Besides giving a summary of historical events, the best lectures and the most comprehensive text books can do little more than lay down general principles. Guided by these principles, and by the instructions they may have received, Naval Officers, in deciding difficult questions, must still mainly rely on their own good sense, judgment, and discretion. These qualities have not generally been wanting in Naval Officers, and were undoubtedly displayed by the Officers who took part in the transactions on the south-east coast of Spain, so ably described in Captain Dyer's paper.

The following extract from a speech by Earl Russell, in the House of Lords, during the American Civil War, may serve as an appropriate conclusion to these notes and remarks:—

"For my part, I have found that the Officers of Her Majesty's "Naval Service, being bound to apply the Law of Nations according "to the rules with which they are furnished, have, generally speaking, "applied them with remarkable sense and discretion, and in a spirit of "equal firmness and moderation, showing themselves disposed always "to maintain the rights of the British Crown and the honour of the "British flag, but at the same time to do nothing for the purpose of "irritation or of mere vexatious interference."

* Parliamentary Papers, pp. 11 and 17.